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"It will flourish, if naturalists, chemists, antiquaries, philologers, and men of science in different parts of *Asia*, will commit their observations to writing, and send them to the Asiatic Society at Calcutta. It will languish, if such communications shall be long intermitted; and it will die away, if they shall entirely cease."

Sir Wm. Jones.

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CONTENTS.

No. I.

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No. II.

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Page

No. III.

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PART II.—PHYSICAL SCIENCE.

No. I.—1866.

Physical Character of the Karens.—By the Rev. F. MASON, D. D.

[Received 7th January, 1865.]

KARENS.*

The name Karen has been adopted from the Burmans, who apply it to various uncultivated tribes, that inhabit Burmah and Pegu; but it is used, in these notices, as designating a people that speak a language of common origin, which is conveniently called Karen; embracing many dialects, and numerous tribes. These tribes, though speaking a common language, have no common name with which to distinguish themselves; but in this respect, they do not differ from our own ancestors. Cæsar found some twenty or thirty different tribes in Britain, but it does not appear that they had any common name by which they designated themselves.

* The following pages are offered as answers to "Queries respecting the human race addressed to travellers, by a Committee of the British Association for the Advancement of Science," at the request of Col. Phayre; and embrace all the writer has to say on the general division of the Queries, entitled "Physical Characteristics;" from Query 1 to Query 49.

No answers are given to Queries 5, 6, 7, 8, 9, 10, and 30, relating mainly to anatomy, because satisfactory ones have not been obtained. Nor are answers given to Queries 13, 14, 15, 16, because the writer has already published on the subject of Language in the Journal of the Asiatic Society of Bengal, and in his work on "Burmah." To write again on the subject, would necessarily compel him to repeat considerable of what is already in print, which seemed undesirable.

The word Karen has been supposed to signify *aboriginal*, from *yen** "first," and *ka*† *a formative particle*; but the derivation is European, not Burmese. The Burmans have never been so recondite in naming wild tribes. When the Buddhist missionaries landed at Martaban, they denominated the aboriginal inhabitants *Beloos*, or "Monsters," and the Burmese still retain the name for a tribe of Karens on the borders of Karenee. The subdued Bghais they dispose of as *Lae-Yoing*,‡ "wild men; while the more civilized Mopghas that bring honey and bees' wax for sale, they call *Taubya*,§ "wild bees;" and they find in the dress of another a distinctive name, and call them "Red Karens."

The word *Karen* is probably a Karen word. One of the northern Karen tribes, with which the Burmans must have held most intercourse before they conquered Pegu, call themselves *Ka-yong*, which is sufficiently near the Burmese to be the same word. Then we have a precisely parallel case in the name they give this tribe, which is *Gui-kho*,‖ a Karen word that is manifestly identical with *Kai-khen*, the name the other Karen tribes give them.

Eight distinct Karen tribes are known, who speak dialects so diverse, that they cannot understand each other; and yet, on examination, the larger proportion of the roots of each dialect are of common origin.

These tribes have often several names, and not only are travellers misled by them; but residents often take up wrong impressions and give, for distinct nations, names that refer to the same tribe.

A few of the tribes only have distinctive names for themselves, and all, when speaking to each other, use the word for man to designate themselves; precisely as the Hebrews use the word for man as the proper name of the first man, Adam. Were these terms for man adopted in English, the tribes would be much more accurately distinguished than they are at present. Thus we should have

Pgha-kuyan	for	Sgau.
Pie-yà	"	Bghai.
Prä-kă-yà, or Kă yà	"	Red Karen.
Heu-phlong	"	Pwo.
Peu	"	Taru.
Plau	"	Mopgha.

* ရင် † က ‡ လူရိုင်း § တောပျား ‖ ကဲ့ခို

Pray-kă-yong	for	Kay or Gaikho.
Lau	"	Toungthu.

Sgau, or Pgha-knyan.

This tribe is known by a diversity of names.

Sgau, the name the tribe give themselves.

Burmese Karens, thus designated by some English writers.

White Karens, the name given them by English travellers to distinguish them from the Red Karens.

Myeet-tho, so designated by the Burmese.

Shan, the name the Pwas give them.

Pa-ku, the name by which they are known in Toungoo, and to the Red Karens; but it more properly denotes a sub-tribe of Sgaus.

Shan-ne-pgha, a name given to another sub-tribe of Sgaus.

Wo-wa, a small sub-tribe of doubtful origin, but probably originally Sgaus.

BGHAI, OR PIE-YA.

The Bghais have no distinctive name for themselves, besides Pie-ya.

Bghai is the name the Sgaus give them, and they recognise the name so far as to apply it with an adjective to sub-tribes among themselves.

Bghai-kă-ten, "Bghais at the end," is the name of the Tunic Bghais, as used by the Pant Bghais; because they live at the extremity of the tribe nearest Toungoo.

Tunic Bghai is the name given to the above sub-tribe, by English writers, because they wear tunics or frocks.

Bghai-kă-hta, "Upper-Bghai." The Pant Bghais are thus denominated by the Tunic Bghais, because they live on the streams above them.

Pant Bghai is the denomination by which all the Bghais that wear pants are known to English writers.

A-yaing, or Ka-yen Ayaing, "Wild Karens," is the name the Burmese give to nearly all the Pant Bghai.

Leik-bya-gyie, "Great Butterflies" is the Burmese name of a portion of the Tunic Bghai.

Leik-bya-guay, "Little Butterflies" are other villages of Pant Bghai.

Pra-pa-ku, is the name given by the Red Karens to the Bghais that live near the Pa-kus.

Manu-manau is a Burmese name given to a mixed sub-tribe of Bghais.

Pray is the Red Karen name applied to the Manu-manau and to some other clans related to the Bghais.

Lay-may is Burman for a sub-tribe of Bghais, called Pray by the Red Karens.

Shan-kho is a name given to a Bghai clan in the north-eastern part of Toungoo.

RED KAREN, or KA-YA.

The Red Karens have no name for themselves, except Ka-ya, or Prã-kã-ya.

Ka-yeu-nie, "Red Karen" is the name given them by the Burmese, on account of the red-striped pants they wear.

Bghai-mu-hta, Bghai-mu-htay, names given them by the Bghais, signifying "Eastern Bghai."

Yang-laing, "Red Karens" is their name among the Shan tribes.

The-pya the name by which the Kay people designate them.

Ta-lya a small sub-tribe of Red Karens, are thus denominated by the Red Karens themselves.

Yen-ka-la, the Burmese name of the above clan.

Tha-vie, or Tha-vie-la-kha is a Red Karen name for a people of their own tribe living ten days' journey above them, on the Salween, and who were separated from them when driven from Ava, sixteen generations ago.

In 1861, our Assistant in Karenee reported a singular letter that was sent by them to Karenee; the object of which was not stated distinctly, but it was understood as a challenge to fight. The following is a translation:—

"Now, the words of God and his commands have come to us. Let all men give up the customs of their ancestors, and offerings to spirits, and live in peace. As for us in the land of Tha-vie, we will dwell in peace and obey the commands.

"Nevertheless, at the proper time we will make a feast; and this feast is not a woman's feast, but a man's feast; and when the time arrives to dance, we will dance. And the shades of the dead, and the

spirits will look on. We say to you, if you wish to look on, come and look, and bring sword and spear. We have appointed the month of March for the time of holding the feast."

PWO, OR HEU-PHLONG.

The Pwos call themselves Sho.

Pwo is the name given them by the Sgau.

Meet-khyen is a name given them by the Burmese, signifying "River-khyens."

Talaing-Karens is a designation they have in some published papers, and they are sometimes thus designated by the Burmese, because they are principally found among the Talaings.

Shoung is a name given to a small sub-tribe of Pwos in the north of Toungoo.

TARU, OR PLU.

Taru is the name given to a tribe nearly related to the Pwos by the Red Karens.

Khu-hta is the name they give themselves.

Be-lu or monsters is the name by which they are characterized by the Burmese. A part of the tribe shave the whole head excepting two tufts of hair, one on each temple, which gives them a sufficiently frightful appearance to account for the name the Burmese have given them.

Be-lu-ba-doung is the name given them by the Kay tribes.

MO-PGHA, OR PLAU.

Mo-pgha is the name of one of the villages, from which the missionaries have named the whole tribe; but it is a name they do not recognise themselves. Neither do all call man Plau. Small as is the tribe, there are two or three different dialects among the people, and we have Pie-zau, and Pie-do for man, as well as Plau.

Tan-bya, "Wild Bees" is a name the Burmese give them in some settlements.

Bgha-Pwo is a designation sometimes given them.

KAI, GAIKHO, OR PRAI-KA-YOUNG.

The Kai, or Kay, or Gaikho have no distinctive name for themselves, beyond Pră-kă-young, or Kă-young, their word for man.

Kă appears occasionally as designating the people, but it signifies land in their dialect, and properly denotes the country.

Kai, or Kay is the name given them by the Bghais, but they never use it alone. They make three divisions of the tribe.

Kai-khen "Upper-Kai," often applied to the whole tribe.

Kai-la "Lower-Kai."

Kai-pie-ya "Kai's people."

Gai-kho is the name which the Burmese give them in imitation of the Bghai Kai-kho.

Pa-htoung is the name the Red Karens give them.

Hashwie is a small tribe related to the Kay, and thus denominated by the Bghais.

Hashu is the name they give themselves.

TOUNGTHU, OR LAU.

The Toungthus are related to the Pwos by their language.

Toung-thu is the name given them by the Burmese.

Pa-au is the name by which they designate themselves.

There is nothing to associate this tribe with the Karens but their language, excepting that the people have the appearance of being a Shan tribe.

SHAN KARENS.

The generic name that the Shans give the Karens in their own country is Yang, which is softened in Burmese into Yen, or Yein. Hence we have of the following Karen tribes is the Shan country of which we know little more than the names.

Yang-lang, "Black Karens."

Ying-ban.

Yen-seik.

Yein.

Sok, or Tsok is the name the Shans give all the Karens that reside in the Burmese territories, without distinction of tribe.

PHYSICAL CHARACTERISTICS.

Though the preceding tribes are one in language, they are scarcely one in anything else. They differ materially in their physical characteristics.

The Pwos and Toungthus, that usually inhabit the lowlands, resemble the Burmese, who inhabit similar localities, in their physical traits more than they resemble the Karens that dwell on the mountains. They are a short muscular people with large limbs, larger than

the Burmese; while the mountaineers are usually of little muscle and small limbs. It is a popular idea that mountaineers are stronger, and hardier than lowlanders, but, however, it may be in other lands, it is certain that in Burmah the mountain tribes are weaker people than those who live on the plains. The cause, however, may possibly be other than the locality.

In stature, all the Karens, excepting perhaps the northern tribes, are shorter on an average than Europeans. In a promiscuous assembly of one hundred men, embracing several tribes, two were *five feet seven* inches high, eight were *five feet six* and a half inches, and all the rest were shorter. An intelligent man that measured *five feet five* inches and a *half*, was confident that he was taller than the average of Karens. I should fix the average at from *five feet four* and a *half* to *five feet five*. The shortest man I have measured, is a Bghai chief, who was only *four feet eight* inches high; and the tallest Karen I have seen, was not quite six feet.

A company of one hundred Karen women had only two that were *five feet* one inch high, eight were about *four feet ten;* and the rest shorter. The average cannot be more than *four feet nine*. The shortest woman I have noted, was *four feet five*.

In different villages, the average would vary considerably from the above. A village of Mopghas, on the hills, that can be seen with a glass from the city of Tounghoo, is remarkable for its short men, especially the younger ones. I doubt there being one over five feet high. On the contrary, the northern Bghais and Gaikhos are comparatively tall, perhaps as tall, usually, as Europeans; but they are a small minority; and I attribute their superiority, in part, to the higher and cooler region that they inhabit.

Though small in stature, the Karens appear to be tolerably well proportioned. No prevailing disproportion between different parts of the body has been noted.

In those parts of the body which are not exposed, the northern Karens, at least, are as fair as the Chinese. The young people, both male and female, among the Gai-khos and northern Bghais, often show red and white in strong contrast on their countenances; altogether unlike the uniform clay colour of their more southern relatives. I have met with individuals, who, if seen alone, would be pronounced

part European. Indeed, if not exposed to the sun, some of them would be as fair, I think, as many of the inhabitants of Northern Europe.

The yellow tinge of the Chinese is very distinctly seen on many of the Karens, particularly the females; and yellow, as well as white, is considered handsome, by Karen connoisseurs of beauty.

The hair is straight and coarse, usually jet black; but a few have brownish hair.

The eyes are commonly black, but as we proceed north, many hazel eyes are met.

The head is pyramidal, the breadth of the face across the cheek bones wider than across the temples, and the bridge of the nose rises only slightly above the face. Occasionally a decided Roman nose is seen, but there is still a depression between the eyes not possessed by the Romans. The face is lozenge-shaped, and the whole countenance, in typical specimens, is Mongolian. There is a great diversity in individuals, and these traits are less developed in the more civilized Sgaus and Pwos than in the wilder *Pakus* and *Bghais*.

It is not easy to describe the characteristic countenances of the different tribes, yet there are characteristic differences, which the experienced eye detects. There is considerable too in locality, which affects the countenance, apart from the difference of race. Thus the Sgaus of Tavoy and Mergui can usually be distinguished from the Sgaus or Pakus of Toungoo. Education also affects the countenance. The Karens that have been educated in our Mission schools look like quite a different tribe from their wild countrymen on the hills.

The Karens rarely marry with other races: but among those who are settled near the Burmese, a Burman is sometimes found with a Karen wife, and in every instance that has come under my personal observation, the children have had a strong Burmese cast of countenance. There in a village near Toungoo where there are several of these mixed families; Europeans do not distinguish them from Burmans. Still, persons acquainted with the Karens, readily recognise them as a mixed race. There is a village, however, on the mountains called "Village of Talaingings," that tradition says was settled by a company of Talaing men who fled into the jungles during some of the wars in Pegu two or three centuries ago; but there is very little in the coun-

tenances of their descendants to distinguish them from other Karens. Their faces are a little longer, their cheek bones not quite so widely expanded, and their faces have a little less of the lozenge shape.

BIRTHS.

When a child is born, in some clans the mother, in others the midwife, cuts the umbilical cord, and puts the placenta into a joint of a large bamboo, and wraps it in a rag. The father then takes it and hangs it up on a tree. An abortion is treated in a like manner, but the tree selected is a species of Ficus, and the abortion is supposed to become one of the Cicadæ that are so often heard singing at evening.

On returning to the house, if the child be a girl, the father goes through the pantomime of performing a woman's labours, beating paddy in a mortar, and the like. If a boy, he spears a hog, and, seizing the first man he meets, wrestles with him, to indicate what his son will do when he comes to manhood.

The knife with which the navel string is cut, is carefully preserved for the child. The life of the child is supposed to be in some way connected with it, for, if lost or destroyed, it is said the child will not be long lived.

About the third day, when the navel string sloughs and comes away, the father takes his net, and, with a few friends, goes out fishing and hunting. The success of the party is deemed prophetic of the character of the child. If much fish or game is obtained, he will be prosperous; if little, he will be unfortunate.

On the return of the party, a feast is made, the friends are invited, and the child is purified and named. Children are supposed to come into the world defiled, and unless that defilement is removed, they will be unfortunate, and unsuccessful in their undertakings.

An Elder takes a thin splint of bamboo, and, tying a noose at one end, he fans it down the child's arm; saying:

> "Fan away ill luck, fan away ill success;
> Fan away inability, fan away unskilfulness:
> Fan away slow growth, fan away difficulty of growth:
> Fan away stuntedness, fan away puniness:
> Fan away drowsiness, fan away stupidity:
> Fan away debasedness, fan away wretchedness:
> Fan away the whole completely."

The Elder now changes his motion and fans up the child's arm; saying:

"Fan on power, fan on influence:
Fan on the paddy bin, fan on the paddy barn:
Fan on followers, fan on dependants:
Fan on good things, fan on appropriate things."

He next takes a bit of thread that has been prepared for the purpose, and tying it round the child's wrist, says: "I name thee A. B.;" using the name that the parents had previously determined upon.

Sometimes a name is selected from among their ancestors, or other relatives; but in such cases they are always careful to select one whose bearer was rich, or valiant, and prosperous; ever avoiding the poor and unfortunate, as they suppose the name influences the character of the man.

Often a name is selected indicative of the state of the parent's mind at the time the child is born. A man rejoices at the birth of a son, and he names it "Joy." A mother is suffering, and she calls her daughter, "grief." Another has a son born when he is hoping for deliverance from Burmese oppression, and the advent of White Foreigners, so he names him "Hope."

Frequently a child is named from some circumstance connected with its birth. One is called: "Father-returned," because the father returned from a journey just as the child was born; and another is named "Harvest," because born at harvest time. For like reasons we have, "New-house," "Sun-rise," "Evening," "Moon-rising," "Full-moon," and "February."

Sometimes the child is named from its appearance, and hence we meet with the names "White," "Black," and "Yellow." "White" is about as common a name in Karen, as Smith or Jones in English.

The animal, vegetable and mineral kingdoms all occasionally furnish names. There are "Tiger," "Yellow-tiger," "Fierce-tiger," "Gaur," and "Goat-antelope;" "Hornbill," "Heron," "Prince-bird," and "Mango-fish;" "Eugenia," "Job's-tears," "Cotton," "Gold," "Silver," and "Tin;" with many others of a like character.

When the child grows up, and developes any particular trait of character, the friends give it another name, with "father" or "mother" attached to it. Thus, a boy is very quick to work, and he is named

"Father of swiftness." If he is a good shot with a bow and arrow, he is called "Father of shooting." When a girl is clever to contrive, she is named "Mother of contrivance." If she be ready to talk, she becomes "Mother of talk."

Sometimes the name is given from the personal appearance. Thus, a very white girl is called "Mother of white cotton;" and another, of an elegant form, is named "Mother of the pheasant."

Occasionally, the name refers to locality. Thus, one living near the Sitang, is "Father of the Sitang;" and another, on the borders of the Thoukyekhat, is "Father of the Thoukyekhat."

Frequently a second name is given without "father" or "mother" being attached to it. Thus, a handsome young person is denominated "Yellow-rising sun;" and one with remarkably long hair, "Horse-tail."

When a man is married, and has a child born to him, his name is changed again to the father of that child. The mother's name is changed in like manner. Thus, I have a Bghai writer called Shie-mo, and his father is known as the "Father of Shie-mo; and his mother, as the "Mother of Shie-mo."

Where there are two persons of the same name, they are distinguished by appending to their names the names of the villages where they reside; analagous to the Norman *de* followed by the name of a place.

The Red Karen ceremonies, at the birth of a child, differ considerably from those noted above. With them, after the child is three days old, the time at which the mother is deemed convalescent and able to walk out, a feast is made by the parents, and the house is open for all to come and eat and drink who choose. All who come are treated as brethren. After the feast, the mother takes the child in a wrapper, on her back, and goes down out of the house. She is then supposed, by a legal figment, to proceed to the paddy field, but in fact she goes out a few yards, digs the ground a little with a hoe, or spade, pulls up a few weeds, and returns to the house. These are symbolical acts, by which the mother pledges herself to labour for the support of the child. The mother next carries her babe to the houses of her near relatives, where the people visited present the child, if a boy, with silver or iron; if a girl, with beads, or a chicken, or a pig.

After these preliminaries, the child is named; often after some person that has been visited who made handsome presents; and always

after some relative, that the memory of their ancestors may be preserved.

Infanticide is rare. Occasionally, when the mother dies, the infant child is killed and buried with her; and I have known a woman confess that she killed her little sister, soon after her birth, because it was ugly; but such things are not common. Children are not exposed.

No measures are taken to alter or modify the form of a child, or any of its limbs. It is carried about in a wrapper, naked, till it can walk, when it is sometimes clothed in a loose tunic; but more often, it is allowed to run about naked. No modification of the limbs is practised.

Among no people are children taught so little as among the Karens; and nothing is taught them to modify the character. They grow up like weeds, and are remarkable for nothing so much as for their wilfulness and disobedience. Yet the Sgaus have a very stringent injunction to obedience to parents. The Elders say:

"O children and grandchildren! respect and reverence your mother and father; for, when you were little, they did not suffer so much as a musquito to bite you. To sin against your parents, is a heinous crime.

"If your father or mother instruct or beat you, fear. If you do not fear, the tigers will not fear you."

They are also taught to obey kings; another of the commands of the Elders being: "O children and grandchildren! obey the orders of kings, for kings in former times obeyed the commands of God. If we do not obey them, they will kill us."

There is nothing remarkable in the sports of the child.

The age of puberty may be set down at from twelve to fifteen years. The people not having had the means of keeping their ages, nothing precise can be affirmed that depends on a knowledge of the age. The Karens consider fifteen as the marriagable age.

While writing, six Karens came in, and on inquiry, one says his mother had five children, two say their mothers had eight, two belonged to families of twelve children, and one man of about fifty years of age is the last surviving child of thirteen by one mother. Women that live to forty-five years of age probably bear on an average from nine to ten children. The Karens consider ten as the proper complement.

A verse from an old song intended to teach the duty of children taking due care of their aged mothers, says:

> "A mother can bear ten children,
> A child cannot bear ten mothers;
> A mother bears ten children
> And her strength is exhausted."

Twins are very uncommon; much more so than among European nations; and I never heard of more than two at a birth.

A large family is deemed a great blessing. When seated around the fire at night, they sometimes sing:

> "People's Kyee-zees many, I covet not,
> People's money much, I covet not,
> I covet young paddy ten cubits high,
> Good children and good grandchildren."

The proportion of sexes among adults is remarkably equal, for it is very rare to find either man or woman over twenty-five years of age that is not married or has been married. The proportion in infancy cannot be very diverse.

Children are reared with difficulty. Large numbers die in infancy from want of care, and from ignorance of the proper way to manage the diseases of children.

Nothing remarkable in their senses has been observed, excepting that their eyes are uncommonly good in seeing objects at a distance; but which may be the result of habit. When I have shown them the villages on the distant hills through my glass, and asked if they did not see them plainly; the reply has often been: "Yes, but I can see them about as well without the glass."

The women bear children to quite as late an age as Europeans. Women, that I should judge to be between forty and forty-five, may be often seen with children at the breast.

Three years is the period for which a child is deemed entitled to his mother's milk; but they are oftened suckled longer. It is not uncommon to see a woman suckling her babe at one breast, and its elder brother or sister at the other.

BETROTHAL.

The Karens go on the principle that marriages are made in heaven. They believe that parties who marry do so in accordance with an engagement into which their sentient spirits entered in the presence of God, before they were born.

It is a very common practice among all the tribes, except the Red Karens, for parents to betroth their children while young, if not in infancy. They have an idea that children are benefitted by it. If a child is sickly, the parents say, "We had better seek a wife for this boy. A wife may invigorate him and make him stronger."

Some one then who has a daughter is selected, and if the parents are agreed, and the fowl bones give a favorable response, a feast is made, and the children are betrothed. The feast is provided by the parents of the boy, and one of the Elders offers the prayer of betrothal, saying: "Lord of the land and water, Mokhie of the land and water; these two are engaged to be united in marriage. May they have long life, may they produce seed, may their shoots sprout forth, may they grow old together!

After a boy and girl have been betrothed, should they, on coming to marriageable age, be unconquerably averse to the union, the parents say: "Ah! their spirits did not consent, their guardian angels did not make the agreement."

The young people sing:

"God and the spirit;
Without their *consent*,
No marriage is made.
God and the spirit,
And with their consent
No marriage is staid."

Should there be a mutual desire to sever the engagement, the parents of the youth go to the friends of the girl; and after the introductory remark that the union does not appear to have been agreed to in heaven, they say: "They were not planted together, they were not sown together, and they do not love each other. Water spilt, leaves the vessel empty; flour thrown out, leaves the basket empty. There must be the loss of half, and the paying of half." Then the parents of the girl pay half the expenses of the feast at the betrothal.

Engagement.

When a young man wishes to take a girl for a wife, the first persons to be consulted are her parents. If they make no objections, he employs a go-between to transact the business for him.

The go-between takes a fowl and gives it to an Elder who consults its bones, and if the response is unfavorable, the match is broken off and no further proceedings taken.

When the fowl's bones are read as approving the marriage, the go-between goes to the parents of the girl, when, in some sections, the following form of dialogue takes place:

Go-between.—"Now I will creep up thy stairs, I will tread on the steps of thy ladder. Thou plantest up large house posts, thou flattenest out wide bamboo planks. Thou callest thyself the master of the house, a good man. When the sun rises, it shines upon thee; when the moon rises, it shines upon thee. Thy head is as large as a still pot, thy tongue as long as the gigantic bean pod. How wilt thou reply? The children lift their eyes on each other. They lift their hearts on each other's heart. Wilt thou approve?"

Girl's Guardian.—"Man is the horse's tooth; the elephant's tusk. Woman is a tree, a bamboo. We *are* the woman, the female. We cannot reach distant waters, nor arrive at far off lands. We dare not seize those who seize us, we dare not strike back again. The man can reach waters, and arrive at distant lands. Can he take upon himself the charge of a house and a field?"

Go-between.—"Fear not, be not anxious, for the house and the field. Mother dying, occupy mother's chamber; father dying, occupy father's hall. By day, there is one sun; by night, there is one torch. Fear not, be anxious for nothing."

Girl's Guardian.—"If thy word is true to thyself; if thy language is faithful to thyself; if thy word is one, thy foot-print one—Let not the tree depart from its shadow, let not man leave his place—very good. Thou art a hunting dog, thou scentest the covert; thou trackest the game. Art thou satisfied?"

Go-between.—"I am a hunting dog, and in scenting the hiding place, and tracking the game, I have got to thee."

Girl's Guardian.—"Thou art a hunting dog. What ornaments hast thou brought? Let me take a look at them."

When the work of the go-between is done, the friends of the young man take a hog, an ox, or a buffalo, according to their circumstances, and, leading it to the dwelling of the parents of the girl, they kill it and examine its gall bladder. If the bladder is full, they say the omen is favourable to the union; but if flaccid, containing little liquid, it is deemed unfavourable. Still, a feast is made, but it is eaten in sadness, and the people murmur, "If they are married, they will have no children; they will be unsuccessful in their undertakings, and they will die young." Sometimes the marriage is broken off, and sometimes it proceeds.

If the gall bladder be plump, there is great rejoicing, and all say, the couple will live to old age, and have a numerous posterity. Before partaking of the feast, an Elder takes a bit of the liver and viscera of the animal together with boiled rice on a plate, and, pouring them out on to the earth, prays; "Lord of the heavens and earth, Lord of the lofty mountains and high hills, we give thee food and drink. May these two persons prosper and be successful, may they have a posterity, may they live to old age, that they may bring up sons and daughters." After the prayer, the elders eat, and then all the people eat after them. After eating, they drink spirits, beat kyee-zees, dance, and sing songs.

After this engagement feast, sometimes the marriage takes place in a few days, but frequently, for various reasons, it is delayed for a considerable period, sometimes for years; and when the delay is protracted, it is not uncommon for the engagement to be broken off.

Should the girl refuse to fulfil her contract, she must pay all the expenses of the engagement feast with interest. "If a hog was killed, she must repay a buffalo. If a horse was offered, she must repay an elephant; and there is the shame besides."

These exaggerated demands are never exacted to the letter. In general terms it is said: "If a man breaks his engagement, he loses his outlay; if a girl breaks her engagement, she must pay a fine."

If a young man wishes to break the engagement, he publicly declares that he will sacrifice all the affair has cost him, and ask no return: "Let the fowl be," he says, "as if the hawk had taken it. Let the food I furnished the parents be as if the tiger or leopard had devoured it. Let the presents I made her relatives be as if sunk in

the water, or destroyed by fire." After this public declaration, the girl is considered at liberty to receive proposals from others; which, without it, she is not.

Marriage.

If there are no obstacles to an immediate union, after an interval of two or three days, the relatives of the bride conduct her to the house of the bridegroom's parents, with a procession of her friends blowing trumpets. When the bride ascends the ladder into the house, water is poured on her abundantly from the verandah, till her clothes are wet through. She then eats with the bridegroom's relatives, and, attended by her female friends, she goes into the chamber. The young man's friends make presents to all the party, giving the most valuable to the relatives of the bride.

When the time for the company to separate approaches, two of the Elders take a cup of spirits, which is called "the covenant drink," and one speaks for the bride, and the other for the bridegroom.

One says; "Now the woman is thy wife, thy daughter-in-law, thine *own* daughter, *thy own* wife who will live with thee. Should she be drowned, should she die by a fall, should she be bitten by a poisonous snake, we can say nothing. But should she be killed in a foray, should she be carried into captivity, should she be put in bonds, thou must purchase her freedom, or obtain the price of her blood."

The other Elder then says: "What thou sayest is true. She is not the child of another, she is my child, my wife, my daughter-in-law. Should she die by accident, I can do nothing. I will lay her out, put food in her mouth, drink by her side, make a funeral feast, and bury her. But should she be carried into slavery in a foray, I will carry a kyee-zee for her redemption, and thou must demand a fine. I will carry spirits to drink, thou must spread out food to eat. We together will purchase the woman. But if we cannot obtain her if she has been killed or is lost, we will demand her price. If I ask her price in kyee-zees, thou must demand it in slaves. We together will make it a reason for making reprisals; and if I am the father of the foray, thou shalt be the mother of it. If I am the head of the foray, thou shalt call the army; and if I call the army, thou shalt be the head of the

foray; and we will work together. If I go first, thou shalt come last; and if I come last, thou shalt go first."

Each one then gives to the other to drink, and each says to the other: "Be faithful to thy covenant."

This is the proper marriage ceremony, and the parties are now married.

Now, the people say, they are man and wife and may live where they choose, with the parents of the man, or with the parents of the woman, or may live independent of both. "They may have food or no food; clothes or no clothes; may live in peace, or fight and quarrel. No one will interfere. It is nobody's business but their own. No one has any right to control them." As a matter of fact, however, the young man usually goes to live with the parents of his wife, and remains with them for two or three years.

Marriage ceremonies among the Red Karens differ materially from those described above. They never betroth their children in infancy, but leave the young people to make their own engagements.

When the parties have agreed to marry, the man kills one or two hogs or fowls in his own house, and makes a feast. To this the friends of the bride, male and female, conduct her; and she eats and drinks, and spends the night in the house with her companions.

In the midst of the feasting, and in the presence of the whole company, the bridegroom offers a cup of spirits to his bride, who drinks it up; and then he asks her: "Is it agreeable?" To which she replies: "Very agreeable."

The next day the bride returns home and makes a similar feast, to which the bridegroom and his friends go. It is now her turn to offer the cup to him, and when he replies to her question: "Is it agreeable?" that it is "very agreeable," the two are regarded as married.

Often, however, the reply is playfully given: "Not agreeable," and then the feasts have to be repeated till the favourable response is obtained.

Marriages, according to the Bghais, ought to be always contracted among relatives. First cousins marry, but that relation is considered undesirably near. Second cousins are deemed most suitable for marriage. Third cousins may marry without impropriety, though that

relation is considered as undesirably remote. Beyond third cousins marriages are prohibited.

CHASTITY.

Among the Red Karens, chastity, both with married and unmarried, is reported as remarkably loose. The commerce of the sexes among young people is defended as nothing wrong, because "it is our custom." The Sau-bwakepho has a regular rule to give six rupees damages in cases of rape; but these are the only cases of *crim. con.* that he entertains in his courts.

Chastity is cultivated, however, by the other Karen tribes; and one means by which it is preserved, is early marriages. The great majority are married soon after the age of puberty. Still, while the young people are as chaste as most people in Christian nations, lapses among the married are not uncommon; but illegitimate children are very rare.

The Sgaus at least are not wanting in good precepts, notwithstanding, for a contrary course. The Elders say:

"O children and grandchildren! do not commit adultery, or fornication, with the child or wife of another; for the Righteous One looks down from above, and these things are exposed to him. Those that do thus, will go to hell.

"If you meet the wife of another, avoid her, and pass on the lower side of the road."

Though the Bghais do not appear to have precisely the same form of command, yet they regard adultery as particularly offensive to God, and as being the cause sometimes of bad crops.

Human nature is the same everywhere, and the betrothal of children in infancy often results in unhappy marriages, and unfaithfulness to the marriage tie.

Sometimes the parties, on becoming of marriageable age, so dislike each other, that they rebel against the authority of the Elders, and form connections for themselves more congenial to their tastes.

POLYGAMY.

Polygamy is neither permitted nor practiced by any of the Karen tribes; but Karens who live in the neighbourhood of the Burmese

sometimes adopt the Burmese custom of taking an additional wife, as they do that of worshipping idols. The Sgaü Elders charge their children:

"O children and grandchildren! If you have one husband or wife, lust not after another, male or female; for God at the beginning created only two, one male and one female."

Divorce.

Divorces are not unfrequent, arising often from marriages being made by the parents of the betrothed in infancy, and the children grow up without any love for each other.

If a man leaves his wife, the rule is that the house and all the property belongs to her. He is allowed no claim on his money and valuables that may be in the wife's possessions, after he has left her. Nothing is his but what he takes with him.

If a woman forsakes her husband, it is usual to allow a share of the property, but no more than the husband consents to allow.

Widows.

Widows retain their husbands' fireplace, and endeavour to support themselves. When young they usually marry again; but if old and unable to support themselves, they look for help to their own relations, and often suffer from neglect. The obligation to treat widows kindly is recognised in theory, but often neglected in practice. The following story from the Bghai gives a too true picture of this matter.

"Formerly, there was a woman whose husband died, and left her to get a support as best she could. All her children were small. Their father had forsaken them, and the mother took care of them in any corner or interstice she could find.

"She had no relations of her own in that country. She had none but her husband's relations, and her husband was dead, and his relations would not help her. She could not therefore get curry to eat, and she fed her children on the sheaths of the blossoms of the wild plantain flowers: these she called to the children "brains," and they knew not, but that was the proper name.

"When the neighbours heard the children say they lived on brains, they said: 'The woman is a witch! Morning after morning it is

brains; evening after evening it is brains. It must be she goes and gets human brains to eat. We cannot get so many brains: and they have no father. Where can so many brains come from?'

"After awhile they concluded they would kill her for being a witch, and they made known their intentions to an uncle of hers. He said: 'Wait till I can go and see her.' When at leisure, he went to see the family. He killed a deer, took the head to the children, and showed the brains to the children, asking: 'Does your mother feed you with brains like these?' They all replied: 'No, uncle, mother feeds us with brains that are bright red.' There are no fibres in them like these.'

"The uncle then repeated his enquiries successively with the heads of a horse, an elephant, a bear, a goat-antelope, a bison, a barking deer, a porcupine, a bamboo-rat, a squirrel, a tupai, a rat, a bird, a fowl, a snake, a frog, a fish, and every kind of animal known in the country; but the children said to all, 'Uncle, our mother feeds us with no such brains as these.'

"He thought to himself; 'It is not this, and it is not that. Surely the woman is a witch, for there is no other kind of brains it can be, but human brains.' So he concluded it was best to kill her.

"However he went out hunting one day more, and all day he met with nothing; so on his return home he plucked two sheathes of wild plantain blossoms, and bringing them into the house, he laid them down by the wash stand. One of the children saw the bright red sheathes; 'My uncle has brought me some brains, I will eat them all myself, I will not give a taste to any one else.' All the children rejoiced greatly, and said 'These are the brains on which mother fed us.'

"When the uncle knew that his niece was not a witch, he almost fainted at the thought of having so nearly consented to her death."

Food.

A Karen is a most omnivorous animal. Always excepting the feline race, he eats every quadruped from a rat to an elephant; and there is scarcely a reptile unacceptable to his palate, from a sand lizard to a crocodile, and from a toad to a serpent. Flying ants and crawling grubs are in his bill of fare; and there is no bird too tough, no fish

too bony for his table. Dogs are not eaten by the Southern Karens, but they are as great delicacies in the Bghai country as they are in China.

To this great mass of animated nature, the whole vegetable kingdom is made to serve as greens. Nearly every weed is a vegetable, and the young shoots of the largest trees serve as spinage. They are so careless about what they gather for greens, that one of our young teachers poisoned himself, not long ago, by the vegetable curry he made by the way, while travelling.

Besides game, the Karens raise hogs and fowls for home consumption as well as for sale, and on festive occasions, those who are able, purchase and kill a buffalo or ox; so they do not seem to lack for animal food. Still, they may be often seen sitting down to rice and vegetable curry, with perhaps a taste of dried fish, and they certainly do not eat as much animal food as Europeans. They live much like the wild beasts of the forest. When chance, or something very like it, sends them a whole beast, they eat meat to surfeit; and then they live on vegetables and rice, till the wheel of fortune turns round again.

The meat is often cut into small pieces and boiled in curry; but it is also frequently roasted or grilled. Fish is often dried, as is also the flesh of game sometimes; but dried so imperfectly, that it usually has a very bad odour.

The Karens distil from rice or millet a kind of whiskey, of which men, women, and children often drink to intoxication. But, like their meat, this too they have not on hand constantly; and they are sober a great part of the year, because they cannot get anything to drink to be intoxicated.

In the matter of quantity, they take more food at a meal than Europeans; and yet, if labouring hard, require to eat more frequently. I have often walked with them, up hill and down; and though I could walk all day, from sunrise to sunset, after an early breakfast with a couple of crackers, and water from the brook by the way; the Karens were always knocked up by noon; and had to stop and eat a hearty meal, before they were able to proceed. This is true of all the natives in the country; but is not quite understood by some of our medical men. Natives are sometimes taken into the hospitals, and

actually starved to death by not having food enough allowed them to keep up their strength.

Dress.

The dress of Karen men, south of Tounngoo, is a tunic, or frock, and a wrapper; the latter serving for a sheet to sleep in at night. Each one, too, usually carries a bag slung over his shoulder.

The tunics of different tribes and clans are distinguished by the peculiar embroidery of each.* The Sgau tunic has red horizontal parallel lines on a white ground. The Bghai tunic, on the contrary, has the red lines perpendicular. The Pgho tunic has a broad belt of embroidery at its base, and the Pahu tunic has a narrow band, and the figures varied for every village, originally distinct families, so the markings are equivalent to coats of arms.

One clan of the Bghais wear tunics, but by far the larger portion of the tribe wear pants, and no tunic; and all the tribes beyond them, as the Gaikho, Tarus, and Red Karens wear pants; but each tribe or clan has some variation in the stripes of figures worked on them, so that, like those who wear tunics, they can be distinguished at a glance.†

Excepting the Red Karens, all the women wear a short gown, petticoat, and large turban, all variously ornamented. The Red Karen women have corresponding articles of dress, but each one is merely a rectangular piece of cloth.

The dresses are made of cotton, which the women usually plant, gather, clean, spin into thread, and weave into cloth. The Northern Bghais and Gaikhos, who raise the silkworm, adorn their dresses with a profusion of silk embroidery.

In some of their clans, the Elder who officiates as high priest in their offerings, or sacrifices, has a longer and more ornamented tunic presented to him than ordinary, but nothing in their traditions has been found to explain the reason.

To describe the different modes of ornamenting their dresses, would require a long article by itself, and a series of drawings.

* There is one exception. The Mopghas wear the same tunic as the Tunic-Bghais, but why, no reason is known. They speak widely different dialects.

† There is one exception. The Northern Bghais, and the Gaikhos wear the same pants.

Tattooing is a practice quite foreign to all the Karen tribes, excepting the Red Karens, who are all tattooed across the back with a figure resembling the rays of the rising sun. They can give no account of the origin of the custom. Karens who are brought in contact with the Burmese and Talaings, often adopt their customs, so that Karens are often found, especially among the Pghos, tattooed and dressed like Burmans.

No characteristic mode of amusement has been observed. The Karens dance, wrestle, and show their agility much like the other nations around them.

Games of chance are not unknown to the people, but they are little addicted to them, and never bet on them, unless they have been corrupted by the Burmese or Shans.

Every village has a good complement of old people in it, and I have met with two men, who considered themselves a hundred years of age. Every village has persons over sixty, seventy is not uncommon, eighty is rare, but ninety is met occasionally.

No marked difference has been noticed between the sexes in respect to longevity.

Sickness.

Where diseases are not deemed contagious, ordinary attention is bestowed upon the sick by their friends and relatives; but when contagious diseases appear, like the small-pox, the whole population seems struck by a panic, and they abandon their houses and scatter into the jungles, where they build booths, and remain till they consider the disease to have passed away. They deem the cholera as contagious as small-pox, and though husbands and wives, parents and children will unite and watch each other to the end; yet all often run away, as soon as a person is dead, and leave him unburied. It is extremely difficult to get people buried in times of cholera.

The Karens attribute diseases to the influence of unseen spirits, and hence, to cure them, they resort to making offerings to appease the spirits that are supposed to be offended. They have twenty or thirty distinct names for different offerings that are made for the sick. They do not, however, exclude the use of medicine altogether; and the Karen Elders have a large Materia Medica, consisting of roots and

herbs, leaves and bark, to fall back upon when the offerings do not prove efficacious.

From satisfactory statistics the annual death rate of the Mountain Karens has been ascertained as a little over two and a half per cent., or about the same as in London. The same years that these statistics were collected, the death rate among the acclimatized European soldiers in Toungoo, was only one per cent. The difference should be attributed, it is believed, to difference in constitution, difference in habits, and difference in treatment of the sick; and not to locality. The Karen Mountains appear as healthy as the Scotch Mountains, or the Mountains of Pennsylvania. That something does affect the death rate besides the locality, is manifest from the deaths in the Toungoo jail. The very years that one man only in a hundred was dying in Cantonments, from eight to seventeen in a hundred were dying in the jail.

Karens lack vigour of constitution, and therefore present a weak resisting power to disease. They are subject to intermittent fevers throughout life. I have prescribed to shivering infants at the breast and to shaking old men of threescore and ten. An European does not escape them, but he has a strong constitution, which struggles hard, and if it comes off victor, it is a victor for life. For the first four years of my jungle travels, I had fever every year, but for thirty years since, with one slight exception, I have been entirely exempt. Bites from land leeches often result in bad sores on Karens; while an European will sit down and pick off a dozen from his legs after a walk, without the slightest subsequent inconvenience. In some localities, there is a species of gad fly that bites severely, and its bite is often followed by an ulcer on a Karen; while I have had the backs of both my hands dotted all over with blood spots from their bites, without suffering anything beyond the temporary inconvenience.

The Karens are a dirty people. They never use soap, and their skins are enamelled with dirt. When water is thrown on to them, it rolls off their backs, like globules of quicksilver on a marble slab. To them, bathing has a cooling, but no cleansing effect. Dirt is death's half brother, and is the father of a host of skin diseases to which the Karens are subject. About half of them have the itch, and

many in the form of dreadful sores. Shingles, and fish-skin, and ring-worm are nearly as common as *psora*.

Many diseases, common to all nations, are much more fatal to Karens than to Europeans. The measles are as fatal as the small-pox in Europe, and the hooping cough often makes sad havoc among children. I have known more than twenty die of this disease in a small village of some two hundred inhabitants.

Consumption kills a few, dropsy more, dysentery many, and occasionally considerable numbers are reported to me as dying of fevers; and yet I have never met with a single case of fever among the Karens, that did not yield to medicine. Enlarged spleen is very common, and is sometimes fatal. Ulcers do not kill, but they are as common as skin diseases, and are in great variety.

There is a disease very prevalent among the Sgau tribes, in which large ulcers appear on the limbs. I have had patients brought to the towns, where they have been sent to the hospitals; and sometimes they have been slightly benefited; but in no case has a cure been effected by European treatment; and I have never found a Surgeon who understood the nature of the disease. One said: "It is not leprosy;" but I think it is a kind of leprosy. Another remarked on the cases submitted to his treatment: "I cannot help thinking there is something venereal in it." This the Karens uniformly deny, but I have certainly seen cases in which both legs were masses of what appeared to be incurable sores completely cured, by severe salivation administered by a Burmese doctor; which favours the idea of the venereal character of the disease; but I have seen others die under the same treatment. The disease is hereditary in most instances, but whenever an ulcer appears, the Karens consider it infectious, and will not have the patient in the same house with them. They insist on his living in a separate house, as much as they would a leper. The Burmese, however, do not consider the disease infectious, in which they are partly correct. The Bghais say it is a foreign disease, and some call it "the Pakü disease," and others the "Burmese disease;" while the Burmese in some sections call it "the Martaban disease," and in others "the Toungoo disease."

Goitre is common on the hills in special localities. It abounds in one village on the granite mountains, while villages three hours' walk

distant are nearly exempt, though located on the same hills, with the same geological formation. Three or four days' journey beyond this, in an extensive region, where the rocks are exclusively secondary limestone, goitre is again found in excess, while other villages, on the same limestone range, are quite free from the disease. In neither of these districts has any metallic mineral been found. Still, there must be something special in the localities where it abounds to produce it; but what that is, remains to be discovered. All that can be said of it with certainty is, that it is a disease of the hills, for it is not found on the plains; nor did I ever meet with it on the hills in the Tenasserim Provinces. The Karens attribute it to the soil, and say that the disease is caught by eating beans, pumpkins, and other vegetables raised in the infected locality, and by drinking the water that runs through it. Their theory has probably some foundation in fact.

Fowls and hogs that the Karens raise, are occasionally attacked by a violent disease by which they die off as if they had the cholera; and buffaloes on the plains are subject to a like complaint.

Worms.

Entozoa are very abundant. The round worm, *ascaris lumbricoides*, is often vomited up by Karens, both children and adults. The common tape worm, *tænia solum*, is a common inhabitant of the bowels, as are also thread worms, *ascaris vermicularis*.

Death.

When an elder among the Bghais, with a large number of descendants, dies, the people build a place in the hall for the deposit of the corpse, and they hew a coffin out of the body of a tree, and hew a cover for it, like the Chinese coffins.

The body lies in state three or four days, and during the time men blow pipes, and the young men and maidens march round the corpse to the music. At night, the piping is discontinued, and singing is substituted.

When the piping and marching is not going forward, the exercises are diversified by weeping and mourning; or by the men knocking pestles together, and others showing their dexterity by putting their hands or heads in between, and withdrawing them quickly before the missiles come together again.

Before the burial, an elder opens the hand of the dead man and puts into a bangle or some other bit of metal, and then cuts off a few particles with a sword, saying: "May we live to be as old as thou art." Each one in the company goes through the same ceremonials, and the fragments gathered are looked upon as charms to prolong life.

When about to bury the corpse, two candles made of bees-wax are lighted, and two swords are brought. A sword and a candle is taken by the eldest son, and a sword and a candle by the youngest; and they march round the bier in opposite directions three times, each time they meet exchanging swords and candles. After completing the circuits, one candle is placed at the foot of the coffin, and the other at the head.

A fowl or a hog is led three times round the building in which the body is placed, and on completing the first round, it is struck with a strip of bamboo once; on completing the second round twice; and at the third round it is killed. If a fowl, it is killed by twisting its head off. The meat is set before the body as food.

Young people are buried in a similar manner, but with some abridgement of the forms.

When the day of burial arrives, and the body is carried to the grave, four bamboo splints are taken, and one is thrown towards the west, saying: "That is the east." Another is thrown to the east, saying: "That is the west." A third is thrown upwards towards the top of the tree, saying: "That is the foot of the tree;" and a fourth is thrown downwards, saying: "That is the top of the tree." The sources of the stream are then pointed to, saying: "That is the mouth of the stream;" and the mouth of the stream is pointed to, saying: "That is the head of the stream." This is done, because in Hades everything is upside down in relation to the things of this world.

The body is then buried, and the grave filled in without further ceremony, and when the top of the grave has been neatly smoothed off, a little fence of trellis work is built around it. Within this fence, boiled rice and other food is placed for the dead.

On returning from the grave, each person provides himself with three little hooks made of branches of trees, and calling his spirit to follow him, at short intervals, as he returns, he makes a motion as if hooking it, and then thrusts the hook into the ground. This is done

to prevent the spirit of the living from staying behind with the spirit of the dead.

After the funeral, the grave-digger washes his clothes, or the neglect to do so renders him unfortunate. Married children may dig the grave for a parent, but young ones are prohibited. They must hire some one to do the work, and give him five rupees.

FEAST FOR THE DEAD.

Like the Chinese, the Bghais make annual feasts for the dead, for three years after a person's death. The feast is made at the new moon near the close of August, or the beginning of September; and all the villagers that have lost relatives, partake in it.

Before the new moon, they prepare food, plantains, sugar-cane, tobacco, betel nuts, betel leaves, and other articles of consumption. A bamboo is laid across one angle of the roof of the room, and on it are hung up new tunics, new turbans, new petticoats, beads and bangles; and at the appropriate time, when the spirits of the dead are supposed to be present, having returned to visit them, they say: "You have come to me, you have returned to me. It has been raining hard, and you must be wet. Dress yourselves, clothe yourselves with these new garments and all the companions that are with you. Eat betel together with all that accompany you, all your friends and associates, and the long dead. Call them all to eat and drink."

After dark, all the people eat bread made of boiled rice beaten in a mortar. The bread is spread down, and the people are invited: "All who are hungry, eat bread here."

Next morning, the first day of the moon, which is deemed the proper feast day, the previous last day of the month being regarded as the day of preparation, all who have Kyee-zees hang them up, and beat them. Then they kill a hog, and make thirty bottles of bamboos. Into one bottle, they put honey, into another water, in a third whiskey, in a fourth salt, in a fifth oil, in a sixth chillies, and into the seventh tumeric. The other twenty-three are laid aside. Loopholes are made to each bottle through which a string dyed yellow is tied.

After setting apart the seven bottles that have been filled, the remaining twenty-three are filled with food indiscriminatively. Some with pork, some with boiled rice, some with bread, some with whiskey, and some with betel. When these are filled, rice bread is rolled

up in leaves, and the rolls piled up together; and then a large basket of open work is woven, into which all these bamboo bottles and the rolls of bread are put.

When the rice and meat is cooked for the feast, after the above arrangements have been made, the food is placed on kyee-zees, or little bamboo stools, if they have no kyee-zees; and they have to be very particular to spread out all the food at the same instant, lest some of the spirits of the dead, being delayed in eating, should be left behind by their companions.

So soon as the food is arranged on the tables, the people beat the kyee-zees and begin to cry, which they say is calling the spirits to come to eat. Each one calls on the particular relative, for whom he has prepared the feast, as father, mother, sister or brother. If a mother, he says; weeping: "O prince-bird mother, it is the close of August, Oh! It is the new moon in September, Oh! You have come to visit me, Oh! You have returned to see me, Oh! I give you eatables, Oh! I give you drinkables, Oh! Eat with a glad heart, Oh! Eat with a happy mind, Oh! Don't be afraid, mother, Oh! Do not be apprehensive, Oh!"

After the weeping exercises are over, the spirits are supposed to have finished their repast, and then the people sit down to eat what is left.

More food is then prepared and put into the basket with the bamboo bottles, that the spirits may have food to carry away with them; and at cock-crowing next morning all the contents of the basket, including the bamboo bottles, are thrown out of the house on the ground; when the same scene of crying and calling on the spirits of the dead is repeated, as detailed above.

They do not weep long, because it is related that in ancient times a woman had a daughter, whom she loved much, and after her death she made this annual festival for her and wept long; when a prophet reproved her, saying: "That is enough. Your daughter says: 'My companions have left me. They have all gone on before.'" Then the mother said: "Seize her for me," and the prophet attempted to grasp her, but he got only a single hem from her garment. Hence the people never weep long, that the departed spirits of their friends may not be left behind by their companions.

Contributions to Indian Malacology, No. VI. Descriptions of new land shells from the Nilgiri and Anamullay Hills, and other places in the Peninsula of India.—By W. T. BLANFORD, *A. R. S. M., F. G. S.*

[Received 3rd February, 1866.]

Of the shells described in the following pages, the greater portion were collected by Captain Beddome, Deputy Conservator of Forests, in the Madras Presidency. This is the ease with all the shells from the Anamullay hills, and also the remarkable species of Spiraculum from the neighbourhood of Vizagapatam. The Nilgiri Hill shells were found by myself in a recent visit, and *H. intumescens* was given to me some years since by Mr. Theobald as *H. Bajadera*, Pfr. I have since collected the shell myself living at Mahableshwar.

1. SPIRACULUM BEDDOMEI, n. s.

Shell very broadly umbilicated, depressed, sub-discoidal, smooth, (?) solid, white with transverse chesnut zigzag stripes. Spire flat or sub-convex, suture deep. Whorls 5, rounded, the last cylindrical, descending gradually towards the aperture, and furnished, 7-10 millemetres behind the peristome, with a short open sutural tube, projecting *forwards* and upwards, not touching the penultimate whorl. Aperture diagonal, circular, peristome double, both lips continuous, the inner slightly expanded, curved back into a shallow angular sinus at the suture, the outer expanded, and inverted upon the upper and dextral margins, rising near the suture into a compressed wing, which is attached throughout on the left side to the penultimate whorl. Operculum horny, concave within, convex without, flattened near the centre, 2 or 3 outer whorls furnished with a free spiral testaceous lamelliform border.

	Millem.	Inches.
Major diameter, ...	27	1.12
Minor ditto, ...	23	.92
Height, ...	10	.4
Interior diameter of aperture, ..	8	.32

Habitat. Kimery Hills near Waltair (Vizagapatam), northern division of the Madras Presidency.

This species is of about the same size as *Sp. hispidum*, Pearson, which it closely resembles in many particulars, though differing in several essential characters. Of these perhaps the most remarkable is the forward direction of the sutural tube, which, in all the previously described species of *Spiraculum* (even if the Moulmein *Opisthoporus Fordoni*, Bens. be included), is retroverted. In several forms of *Opisthoporus*, however, the spiracle projects forward, as in the present species. The wing of *Sp. Beddomei* is much more distinct, higher and more pterocycloid than that of *Sp. hispidum;* the inner peristome, (which is deficient in the last named species), is angularly sinuate beneath the wing, but there is no approach to the deep sub-circular opening of the Indian species of *Pterocyclos*. All the specimens procured by Captain Beddome were dead and weathered, and had lost their epidermis, but the traces which remained, shewed no approach to the hispidity from which the Khasi hill shell derives its name. The operculum has even more resemblance to that of *Pterocyclos tenuilabiatus*, Metcalfe, than has that of *Sp. hispidum*.

This is the first discovery in the peninsula of India of a species of *Spiraculum*, that genus having hitherto only been met with to the east of the Bay of Bengal, in Assam and Burmah, while the subgeneric form *Opisthoporus* occurs in the Malay countries and Borneo. In a country like India, which intervenes between two great zoological provinces, the Malayan, and the Africano-Asiatic, such exceptional occurrences are natural, and instances are known not merely of outlying species, but of genera, such as *Cataulus* and *Cyclotopsis*, peculiar to the Indian peninsula or to Ceylon, though belonging to Malayan or African families. The presence of a *Spiraculum* on the eastern coast of India, is a parallel case to the existence of *Otopoma Hinduorum*, W. Blanf. in Hattiwar. It should also be noted that the discovery of specimens of the two Burmese helices, *H. Castra*, Bens. and *H. levicula*, Bens., on the hills of Orissa, shews that some few Burmese species even have extended their range down the western side of the Bay of Bengal.

2. Nanina (Ariophanta) intumescens, n. s.

Shell sinistrorse, narrowly and sub-obtectly umbilicated, globose, thin, finely, subplicately, transversely striated with obsolete decussating

sculpture, dull fulvous brown, horny, rather lighter in colour just above the periphery and around the umbilicus. Spire convexly conoid, apex very obtuse, suture scarcely impressed. Whorls $4\frac{1}{2}$, slightly convex; the last bluntly carinate, descending very little near the aperture, tumid beneath, compressed around the umbilicus. Aperture large, diagonal, truncately sub-circular; peristome white, subexpanded, margins approaching each other, columellar margin nearly vertical, rather broadly reflexed, partly covering the umbilicus.

	Millem.	Inches.
Major diameter, ...	32	1.3
Minor ditto,........................	26	1.05
Axis, ...	22	0.9

Habitat. Mahableshwar. Western Ghats of Hindustan.

This fine species of *Ariophanta* has long been confounded with *Nanina Bajadera*, Pfr. which is, however, although a variable shell, easily distinguished. *N. Bajadera* is more globose and thicker, being at the same time more transparent, it has much stronger sculpture (and deeper sutures) and is always rounded at the periphery near the mouth, and frequently throughout, while in *N. intumescens*, the blunt angulation is persistent. *N. Bajadera* too has a fine vitreous lustre, while *intumescens* is dull, and the former shell is usually of a greenish olive colour, though varying in this character and sometimes resembling the latter. The animals also shew a difference in colour, that of *N. intumescens* is uniformly, so far as I have seen, dark cinereous, while that of *Bajadera* is much lighter, but very variable. The latter shell is found mostly on shrubs, the former on the ground, and while *intumescens* has as yet only been found at Mahableshwur, 4,500 feet above the sea, *Bajadera* (which is rare at Mahableshwur) abounds on the equally or nearly equally high hills of Singhur and Poorundhur, and along the summit of the Western Ghats at about 2,000 feet. It abounds at Khandalla at the top of the Bhore Ghat.

I have already mentioned, in a previous paper, (An. Mag. Nat. Hist. for February, 1863) that an examination of the type specimens of *N. Bajadera*, Pfr. and *N. ammonia*, Valenciennes, has shewed these two supposed species to be identical. I long doubted the distinctness of the species now described from *N. Bajadera*, but although

I have specimens of the latter from many different places, they are all easily distinguished from *N. intumescens.*

3. N. (*Hemiplecta?*) Sisparica, n. s.

Shell openly perforated, subumbilicated, depressed, rather thin, striated, white with a yellowish brown epidermis, having a rather dull oily lustre. Spire convex, apex obtuse, suture flat, linear, submarginate. Whorls 4, very flatly convex above, apical whorl marked with very fine decussated plicate striation, the last not descending distinctly, but bluntly angulate above the periphery, convex beneath. Aperture oblique, semiovally lunate, white and pearly within, the breadth exceeding the height, peristome thin, margins distant, united by a thin callus, columellar margin very oblique, and triangularly reflexed close to the perforation.

	Millem.	Inches.
Major diameter, ...	37	1.5
Minor ditto,........................	31	1.3
Axis, ...	18	.75

Habitat. Sispara ghat, Nilgiri hills, S. India, rare.

I know of no near Indian ally of this species. *N. Orobia*, Benson, from Darjeeling, which approaches it in some respects, is more globose and more solid, and has impressed sutures. The Ceylonese *N. Chenui*, however, closely resembles the species above described in form, though it is easily distinguished by its peculiar impressed sculpture. I obtained but two specimens, one of which was living, near the top of Sispara ghat. It is remarkable that so fine a shell should have escaped detection before.

The animal differs in no essential character from those of the sinistrorse *Ariophanta* section. It has a large mucus pore at the end of the foot without any lobe above, the mantle is of moderate size, the head and neck granulated, the caudal portion of the body marked by oblique parallel, impressed wrinkles, and broadly margined near the sole with a double, impressed line.

4. N. (*Macrochlamys?*) Hebescens, n. s.

Shell scarcely perforate, inwardly depressed, yellowish or fulvous, thin, horny, dull, marked with very close microscopic impressed

oblique lines above, more polished and radiately striated below. Spire low, apex rather acute, prominent, sub-acuminate, suture deep. Whorls $5\frac{1}{2}$, rounded, the first narrow, the last much broader, very bluntly sub-angulate at the periphery, and tumid beneath. Mouth large, nearly vertical, lunately sub-ovate, breadth exceeding the height; peristome thin, straight, margins sub-distant, united by a very thin callus, columellar margin nearly vertical above, very briefly and broadly reflexed, nearly covering the perforation.

	Millem.	Inches.
Major diameter, ...	15	0.6
Minor, ...	$12\frac{1}{2}$	0.5
Axis, ...	$8\frac{1}{2}$	0.33

Habitat. Anamullay hills. S. India.

This species resembles the Bengal *N. subgesta*, Bs., and the Ceylonese *N. carneola*, Pfr. (as figured by Reeve) in form, but has a duller lustre and deeper sutures, resembling in the latter character some of the Ceylon *Naninæ* of the same section. The microscopic sculpture is peculiar, the impressed lines being very close, but somewhat irregular and wavy. They cause the dull appearance of the surface. An ordinary lens is insufficient to shew them: under a microscope with a $1\frac{1}{2}$ in. objective they are very distinct.

5. N. (*Macrochlamys?*) Lixa, n. s.

Shell obtectly perforate, rather depressly turbinate, very thin, fulvous, horny, dull, obliquely striated and marked with very fine and close impressed lines, also oblique, only visible under the microscope, polished beneath. Spire conical, apex acute, suture impressed. Whorls $5\frac{1}{2}$, convex, gradually increasing, the last much broader, obsoletely sub-angulate at the periphery, tumid beneath. Aperture nearly vertical, roundly lunate, breadth very little exceeding the height. Peristome thin, straight, margins sub-distant, columella nearly vertical and very briefly reflexed above, almost concealing the perforation.

	Millem.	Inches.
Major diameter, ...	$13\frac{1}{2}$	0.54
Minor ditto, ...	12	0.48
Axis, ...	$9\frac{1}{2}$	0.38

Habitat. Anamullay hills. E. side.

This is a shell with a similar dull greasy lustre to the last and owing it to the same cause, *viz*, microscopic sculpture. It is a well marked species. Very possibly, however, intermediate varieties may be found connecting it with *N. hebescens.*

6. N. *(Macrochlamys)* Infausta, n. s.

Shell openly perforated, convexly depressed, very thin, fulvous horny, obliquely finely striated, spire convex, apex distinct, suture scarcely impressed. Whorls 6, flattish above, gradually and regularly increasing, the last not descending, depressed, swollen beneath, obsoletely sub-angulate above the periphery. Aperture oblique, lunate, breadth exceeding the height; peristome thin, margins distant, united by a very thin callus, columellar margin vertical above, briefly and triangularly reflexed.

	Millem.	Inches.
Major diameter, ...	23	0.92
Minor ditto, ...	20	0.8
Axis, ...	$12\frac{1}{2}$	0.5

Habitat. Anamullay hills, S. India.

Three specimens of this species occur amongst Captain Beddome's Anamullay collections. The above dimensions are those of the largest and most perfect specimen. In both of the smaller specimens which measure respectively in their major and minor diameters and axis $19\frac{1}{2}$, 18, 10, and 17, 15, 9 millemetres, there is more or less descent of the last whorl at the aperture, but both specimens have a stunted appearance, and irregular descent of the last whorl is very common in abnormal individuals of all forms of *Helix*.

This species has no very marked character. It is very near *N. vitrinoïdes*, Desh., but may be recognised by its smaller and rounder mouth, narrower last whorl and more convex form. In shape it resembles *H. monticola*, Hutton.

7. Vitrina auriformis, n. s.

Shell very depressed, irregularly ovate, ear-shaped, very thin, striated, polished, with a membranaceous epidermis, greenish or brownish yellow in colour, paler at the nucleus. Spire flat, suture slightly impressed. Whorls $1\frac{1}{2}$. Aperture oval, occupying the whole under

part of the shell, and exposing the interior to the apex; peristome membranaceous.

	Millem.	Inches.
Length, ...	13	0.52
Breadth, ...	8	0.32
Height, ...	$2\frac{1}{2}$	0.1

Habitat. Sispara ghat, Nilgiri hills, Southern India.

This species is very near *V. gigas*, Bens. and still more closely allied to *V. Peguensis*, Theobald, being, however, a more depressed species than either, and more open. It is also less solid than the last named species. I have not met with the animal, which may possibly differ from those of other Vitrinæ.

If the animal resemble those of *V. gigas* and *V. Peguensis*, the occurrence of this mollusk on the western flank of the Nilgiri Hills will be one of the most anomalous with which I am acquainted amongst the land-shells of India, since I know of no other instance of a Malayan type, unrepresented on the Himalayas, of which species occur on the hills of Southern India. A small auriform shell such as this may, however, have been easily overlooked, and the Himalayan Molluscan fauna is, probably, far from thoroughly known.*

The animal of *V. Peguensis* has been partly described by Mr. Theobald who, however, has unfortunately not mentioned the form of the mantle, the presence or absence of lobes covering the shell, nor the existence of a caudal gland, unless by the expression "caudali papilla nulla" is intended to imply its absence; more probably Mr. Theobald's meaning is that the overhanging lobe, so conspicuous in some forms of *Nanina* is absent, the gland existing, as in *Ariophanta* &c.

This *Vitrina* is not the only south Nilgiri species. A larger membranaceous form also occurs, which requires comparison with Mr. Benson's *V. membranacea* from Ceylon.

8. Achatina Anamullica, n. s.

Shell turrito-ovate, thin, finely striated, horny with high vitreous lustre. Spire turrited, sides convex, apex obtuse, suture impressed.

* Mr. Theobald (J. A. S. B. XXXIII. p. 244,) includes *V. gigas* in his list of Himalayan shells, but the species is found on the Khasi hills, the fauna of which differs widely from that of the Himalayas.

Whorls 8, scarcely convex, the last rounded beneath. Aperture oblique, peristome thin, columella moderately arcuate, obliquely truncated below.

	Millem.	Inches.
Length, ...	27	1.1
Diameter,.........................	12	0.48

Aperture 10 millemetres high, 6½ broad. Habitat. Anamullay Hills.

Intermediate in its characters between *A. Nilagarica*, Bens., and the oblong ovate, Achatina of Ceylon.

Captain Beddome's Anamullay collections comprise the following species in addition to those above described :—

Nanina vitrinoides, Desh. var.

N. Shiplayi, Pfr.

N. Indica, Pfr. var.

N. Travancorica ? Bens.

N. Basileus, Bens.

N. ampulla, Bens.

N. auris ? Pfr.

Bulimus Nilagaricus, Pfr. var.

B. physalis, Bens.

B. sp. near B. trifasciatus, Rv., one imperfect specimen.

Cyclophorus Jerdoni, Bens.

C. deplanatus, Pfr.

C. sp. near C. ravidus, Bens. (or possibly an immature *Aulopoma.*)

C. sp. (apparently near C. Shiplayi, Pfr., but finely costulated, possibly the young of an *Alycæus.*)

Pterocyclos nanus, Bens.

Pt. rupestris, ?! Bens.

Paludomus, sp.

Neritina Perrotettiana, Recleiz.

To which there only remains to be added *Cataulus recurvatus*, Pfr., to complete the list of known shells from the Anamullays. I add a few remarks upon the species above quoted.

But one specimen occurs of the shell which I am disposed to consider a variety of *Nanina vitrinoides*. It is small, measuring only 18½ millemetres by 16 in its two diameters, and 8½ in height. It is depressed in form, and of a greenish tinge, but appears to differ in no

essential particular from the Bengal variety. The species has not before, so far as I am aware, been found in Southern India. *N. Shiplayi*, Pfr. inhabits the eastern base of both the Anamullays and the Nilgiris; on the latter hills I have found it at the foot of the Coonoor ghat. The animal is a *Nanina*, closely resembling *N. indica*, Pfr. and *N. acuducta*, Bens., having a large mucus pore at the caudal extremity of the foot without an overhanging lobe, or with but a very rudimentary one. The mantle lobes are small, and the animal in all respects closely resembles that of the sub-genus *Ariophanta*. A solitary specimen of *N. indica* from the Anamullays is very solid and rather strongly marked, the sculpture being less regular than in the common Nilgiri form, and scarcely granulate, the last peculiarity being perhaps due to weathering, as the specimen is decorticate and somewhat bleached. It is a dwarf form, less depressed than the type, and measures 17 and 15 millem. in its two diameters, and 10 in height. The shells found on the Nilgiris vary considerably.

N. Basilens, Bens. (*H. Titanica*, Pfr.), I learn from Captain Beddome, is far from scarce in the teak forests of the Anamullays, a tract 2,000 to 3,000 ft. above the sea, where *N. ampulla*, Bens. also occurs. The range of the latter shell extends a considerable distance to the north in the Wynaud district, where it was found by Dr. Jerdon, if not to the base of the Coorg hills, while *N. Basilens* does not appear to be found north of the remarkable gap in the Western Ghats at Paulghat cherry, which, traversing the very highest portion of the whole chain, divides the Nilgiris from the Anamullies, and through which the railway from Madras to Beypoor passes. Both *N. ampulla* and *N. Basilens* have only been found west of the Hills.

I have not had an opportunity of comparing the shell referred doubtfully to Mr. Benson's recently published *N. Travancorica* with the full description, and the identification is therefore unsatisfactory. The shell referred to *N. auris*, Pfr. is identical with a species found at Neddiwuttom on the Nilgiris, and corresponding closely with Reeve's figure of that *N. auris* in Conchologica Iconica.

The little shell which I have called *Bulimus Nilayaricus*, I was at first disposed to consider a distinct species. It is only 14 millem. in length, and base by 6 in diameter. But some specimens from the Nilgiris are no larger, and there are graduations in size from these to

the typical shells. The solitary specimen of *B. physalis* has only traces of spiral sculpture, but it appears to agree in every other respect with Mr. Benson's description.

A dwarf form of *Cyclophorus Jerdoni*, only 29 millem. in diameter and 19 high, and 2 species of *Pterocyclos*, one of them unquestionably identical with *Pt. nanus*, Bens., are also comprised in Captain Beddome's collections. The second species of *Pterocyclos* of which a single weathered specimen was found, shews no essential distinction from the Bengal *Pt. rupestris*, Bens., but it appears improbable that that form should really exist so far to the south.

Cyclophorus deplanatus, Pfr. some decorticated specimens of which were amongst the Anamullay shells, occurs abundantly on Sispara ghat, at the western extremity of the Nilgiri plateau. A small shell in Captain Beddome's collections, with more colouring than *C. ravidus*, Bens., and ornamented with zigzag transverse stripes, may possibly be a young specimen of that species, but its thin and continuous peristome recalls that of some forms of *Aulopoma*, and the possibility of its belonging to that genus is strengthened by the deficiency of the epidermis close to the peristome. As the Anamullays have already furnished a *Cataulus*, the occurrence of a species of *Aulopoma* is by no means improbable.

The *Paludomus* is perhaps a variety of the species common near Bombay. The little *Neritina Perrotettiana* was previously unknown except in the Pykara river on the Nilgiris.

We have evidently, as yet, only an instalment of the molluscan fauna of the Anamullays. None of the shells above specified are from the higher ranges. So far as they have been collected, there is, as might have been anticipated, a general identity with Nilgiri shells, but at the same time a somewhat closer approximation to the Cingalese fauna.

P. S.—The above paper was written six months ago, and would have been sent for publication in the Society's Journal at once, but that I hoped to be able to procure drawings of the shells for the purpose of illustrating it. In this, I have again been disappointed, and I am compelled to forward the descriptions of the shells by themselves.

In the meantime, however, I have received from Captain Beddome several additional shells from the Anamullay hills collected by him

during the past year. Besides several new species, the collection comprises *Helix Anax*, Bens., and a fine large *Nanina* resembling *N. Cysis*, Bens. but dextrorse, and which is very possibly a large variety of Mr. Benson's *H. Basilessa.* It occurred at a height of 7,000 feet above the sea. I append descriptions of 3 of the new species sent.

9. Achatina Beddomei, n. s.

Shell turrito-ovate, solid, finely and closely sub-costulately striated, dark purplish brown, epidermis in parts having a tendency to assume a dirty cream colour, especially in dead specimens. Spire convex below, slighly acuminate above, apex obtuse, rather inclined to the right, suture impressed. Whorls $7\frac{1}{2}$-8 convex, the last $\frac{2}{5}$ of the entire length, rounded at the base. Aperture nearly vertical, sub-pyriform, milky within; peristome thickened, white, outer margin rather straight, not arcuate, columella deeply curved, lined with callus, sub-obliquely and rather broadly truncated at the base.

	Millem.	Inches.
Length, ...	30	1.2
Diameter, ...	$11\frac{1}{2}$	.45

Aperture 10 millem. long, 6 broad.

Habitat. Anamullay Hills, 5,000 to 7,000 feet (Beddome.)

This is a more solid form than any of the Nilgiri species, and it differs from all of them, and also from the solid Ceylonese forms, in its sub-acuminate apex. It is a well marked species.

10. Achatina textilis, n. s.

Shell ovate-oblong, rather solid, translucent, striated near the suture, smooth, polished, dark chesnut with close vertical and horizontal lines of a greyish yellow colour, varying in breadth and resembling the threads of an irregularly woven cloth. Spire elongated, conoidal with convex sides, apex obtuse, sutures impressed. Whorls 7, convex, the last about $\frac{2}{5}$ of the entire length, rounded beneath. Aperture vertical, truncately semioval, milky within; peristome slightly thickened, white, right margin slightly sinuate toward the base, columella deeply curved, obliquely truncated beneath, margins united by a thin callus.

	Millem.	Inches.
Length, ...	26	1.05
Diameter, ...	13	0.52

Aperture 10½ millem. long, 7 broad.

Habitat. Anamullay Hills, 6,000 feet, (Beddome.)

This is the only indigenous Indian *Achatina* with which I am acquainted, possessing coloured markings. In form it approaches some of the Ceylon *Achatinæ*, and also an undescribed Deccan species.

11. Bulimus trutta, n. s.

Shell perforated, conically ovate, thin, finely striated, light yellowish, with two spiral rows of sub-distant chesnut spots, sub-quadrate in form, on all the whorls, and two spiral chesnut stripes, the lower sometimes very faint, upon the last whorl below the periphery. Spire conical, apex acute, sutures impressed. Whorls 5½, convex. Aperture nearly oval, slightly oblique. Peristome thin, margins united by a thin callus, columellar margin vertical, narrowly reflexed, the reflexed portion meeting the penultimate whorl at an angle.

	Millem.	Inches.
Length, ...	14	.55
Diameter,........................	9	.35

Aperture 7 millem. long, 4½ broad.

Habitat. Anamullay Hills, (Beddome.)

There is some doubt whether the shells above described be adult. They have a somewhat immature appearance, but all the specimens sent, four in number, are of precisely the same size, and the thin peristome is characteristic of the group of *Bulimus Bengalensis*, to which the present species belongs. From that species and its allies, it s easily distinguished by its short conical form.

Catalogue of the specimens of Meteoric Stones and Meteoric Irons in the Museum of the Asiatic Society of Bengal, Calcutta, corrected up to January, 1866. *By Dr.* Stoliczka and H. F. Blanford, Esq. *F. G. S.*

Number.	Date of fall.		Name of locality and geographical situation.	Weight.*	
	Year.	Month and day.		Of the largest specimens.	Of the specimens in the Museum.
			1.—Meteoric Stones.		
1	1492	7th Nov.	Ensisheim, Elsass, France, ...	1 oz. 44 grs.	1 oz. 44 grs.
2	1798	13th Dec.	Benares (near Krakhut) East Indies, ...	1 oz. 347 grs.	1 oz. 347 grs.
3	1803	8th April,	L' Aigle (Dept. de l' Orne) France, ...	1 oz. 434 grs.	1 oz. 434 grs.
4	1807	14th Dec.	Weston, Connecticut, U. S. A. (2 specimens,)	65 grs.	111 grs.
5	1808	22nd May,	Stannem (near Iglau) Moravia, ...	5 oz. 228 grs.	5 oz. 228 grs.
6	1808	?	Moradabad, East Indies,§	287 grs.	287 grs.
7	1812	5th August,	Chantonnay, Vendée, France,...	2 oz. 319 grs.	2 oz. 319 grs.
8	1814	15th Feb.	Bachmut, Yekaterinoslaw, Russia, ...	4 oz. 13 grs.	4 oz. 13 grs.
9	1815	18th Feb.	Duralla, territory of Patyala, East Indies,†		
10	1821	15th June,	Juvenas near Libonnez, Ardéche, France, ...	3 oz. 407 grs.	3 oz. 407 grs.
11	1822	30th Nov.	Bittoura 75 miles N. W. of Allahabad, East Indies,‡	1lb15 oz. 410 grs.	3 lb. 13 oz. 42 grs.
12	1822 or 23	...	Umbalah, East Indies, ...	1 oz. 108 grs.	1 oz. 108 grs.
13	1827	16th Feb.	Mhow, Ghazeepore, East Indies.‡	4 oz. 234 grs.	4 oz. 234 grs.
14	1838	18th Feb.	Akburpore, Sarahanpore, Eas Indies,†		
15	1838	6th June,	Chandakapoor, Berar, East Indies, ...	304 grs.	304 grs.
16	1838	13th October,	Cold Bokkeveldt, Cape of Good Hope, ...	67 grs.	67 grs.

* Weights are given in pounds, ounces and grains.

Note 1.—Specimens with a mark ‡ are besides represented by a cast of the entire stone in addition to the specimens of the original.

Note 2.—Specimens with a mark † are represented by a cast only.

§ According Mr. Piddington the Society possessed in 1845 3 pieces of this interesting meteorite.

Number.	Date of fall.		Names of locality and geographical situation.	Weight.	
	Year.	Month and day.		Of the largest specimens.	Of the specimens in the Museum.
17	1841	12th June,	Château Renard, Loiret, France, ...	5 oz. 328 grs.	5 oz. 328 oz.
18	1843	25th March,	Bishopsville, S. Carolina, U. S. A. (2 specimens,)	160 grs.	223 grs.
19	1843	6th July,	Manegaon, Kandeish, East Indies, (2 specimens,)	268 grs.	1 oz. 67 grs.
20	1846	Found in the Society's collection.	Assam, East Indies, ...	10 oz. 96 grs.	10 oz. 96 grs.
21	1847	27th Feb.	Iowa, Linn County, U. S. A., ...	6 oz. 426 grs.	6 oz. 426 grs.
22	1850	30th Nov.	Shalka, 10 miles S. of Bancoorah, East Indies, (several specimen,) ...	2lbs 15oz. 100grs.	5lbs. 7oz. 140grs.
23	1852	23rd Jan.	Nellore near Madras, East Indies,†		
24	1852	4th Sept.	Mezö, Madaras, Marasch, Transylvania, ...	15 oz. 348 grs.	15 oz. 348 grs.
25	1852	2nd Dec.	Bustee, (between Goruckpore and Fyzabad,) East Indies,†		
26	1853	6th March,	Segowlee, Sarun, East Indies, (3 specimens,)‡	8lbs 11oz. 266grs.	19lbs. 1oz. 61grs.
27	1855	5th August,	Petersburgh, Lincoln country, Tennessee, U. S. A., ...	42 grs.	42 grs.
28	1857	28th Feb.	Parnallee, S. of Madura, East Indies,†...		
29	1860	28th March,	Kheragur, N. of Bhurtpoor, Agra, East Indies, ...	4 oz. 412 grs.	4 oz. 412 grs.
30	1860	14th July,	Dhurmsala, Punjab, East Indies, (2 specimens.)	15 oz. 306 grs.	1 lb. 7 oz. 66grs.
31	1861	12th May,	Goruckpore (Pijsnaisi), East Indies, (3 specimens),‡	10 lbs. 12 oz.	
32	1863	11th August,	Dacca (Shytal 40 m. N. of) East Indies, (several specimens,)‡ ...	‖	‖
33	...	...	Shergotty, ... ¶	10lbs. 6oz. 12grs.	11lbs 2oz. 380grs.
34	...	...	Jessore,‡	3lbs. 9 oz. 259grs.	3 lbs. 9 oz. 259grs.

‖ The total weight at the fall was somewhat *exceeding* 5 lbs. 1 oz. 313 grs.
¶ The total weight of the original specimens which are as yet undistributed.

Number.	Date of fall.		Names of locality and geographical situation.	Weight.	
	Year.	Month and day.		Of the largest specimens.	Of the specimens in the Museum.
			2.—METEORIC IRONS.		
1	1776		Knasnojarsk, Teniseisk, Siberia (Pallas-iron,) (2 specimens,) ...	324 grs.	1 oz. 95 grs.
2	1784		Toluca, Xiquipilco, Mexico, (2 specimens.)	11 oz. 71 grs.	17 oz. 139 grs.
3	1792	Found,	Zacateras, Mexico, ...	1 oz. 87 grs.	1 oz. 87 grs.
4	1811		Ellbogen, Bohemia, (2 specimens,)	310 grs.	1 oz. 66 grs.
5	1814	Disc.	Texas, Red river, U. S. A., ...	18 oz. 180 grs.	18 oz. 180 grs.
6	1815	Found.	Lénarts, Scharosch, Hungary, ...	2 oz. 342 grs.	2 oz. 342 grs.
7	1827	Found,	Atacama, Belivia, S. A., ...	3 oz. 276 grs.	3 oz. 276 grs.
8	1840		Coke Country (sevier-iron), Tennessee, U. S. A., ...	188 grs.	188 grs.
9	1840		Smith Country, (Carthago) Tennessee, U. S. A.,...	239 grs.	239 grs.
10	1841	Found,	Kuffs Mountain, Lemington Country, U. S. A., ...	244 grs.	244 grs.
11	1843		Arva, Hungary (2 specimens,)	1 oz. 207 grs.	1 oz. 207 grs.
12	1847	14th July,	Braunau, Bohemia, ...	7 oz. 29 grs.	7 oz. 29 grs.
13	1847	Disc.	Seelaesgen, Neumark, Brandenburg, Prussia, ...	5 oz. 284 grs.	5 oz. 284 grs.
14	1850		Tuczon, Onora N. Mexico, ...	385 grs.	385 grs.
15	1856		Tewall Hill, Madison Country, N. Carolina, U. S. A., ...	2 oz. 31 grs.	2 oz. 31 grs.
16	1857		Tula, Netschaèvo, Russia, ...	4 oz. 420 grs.	4 oz. 420 grs.
17	1861		Robertson Country, Tennessee, U. S. A., ...	1 oz. 249 grs.	1 oz. 249 grs.
18	1861	Disc.	Bittersgrün, Saxony, ...	10 oz. 232 grs.	10 oz. 232 grs.

*Observations on the Astronomical points determined by the brothers Schlagintweit in Central Asia.**—*By Captain* GOLUBIEF.

From the Journal of the Imperial Russian Geographical Society. Part 4th, 1861.

[Received 11th January, 1866.]

During the current year, the first volume of the Narrative of the Scientific Expedition of the brothers Schlagintweit to India and High-Asia, extending over a period of four years, from 1854 to 1858, has made its appearance. This remarkable production is all the more valuable, inasmuch as it will not only embrace the results of the explorations of the brothers Schlagintweit, but likewise those of many learned travellers who were their predecessors in this field of inquiry. The first volume contains a collected series of astronomical and magnetic determinations. The number of the points for which geographical co-ordinates are given is 112, but the degree of their exactness differs considerably. Many of the points for which co-ordinates are given were obtained from Indian triangulations; but many others were determined from march-routes alone. The determinations which are less exact, belong naturally to the northern portion of the journey, to Tibet and Turkestan. The corrections which it would be necessary to make in the existing maps, in consequence of the Schlagintweits' determinations, would be very considerable, particularly in longitudes. Thus, for instance, Lé, in Ladak, is alleged to lie 44′ more to the West than was originally supposed, and altogether the whole of western Tibet would have to be removed about 20′ to the westward. The changes in the latitudes are less extensive, the highest do not exceed 10′, as in the case of Balti. The Karakoram pass, the highest point attained by Europeans who had preceded the Schlagintweits, lies more northwards by 11′, and the same distance farther to the West than marked on any previous map.

* This paper was read at a general meeting of both sections of the Russian Geographical Society. The president of the section of physical geography, M. Semënof, who had only just returned from abroad, took occasion to express his own doubts as to the correctness of some of the determinations and conclusions of the brothers Schlagintweit. He communicated to the members present that these results, which bear evident traces of haste, are regarded with equal doubt by the learned in Germany. The extensive range of the labours, the multiplicity of the collections and observations which devolved on the celebrated travellers, produced the confusion and irregularity apparent in their observations and collections.

The weight which is to be attached to these corrections, must depend on the degree of exactness which regulates the scientific labours of the brothers Schlagintweit; but unfortunately, in the volume that has been issued, this consideration is not dwelt on, that is to say, the probability of errors in the determinations is nowhere alluded to. The determinations themselves are not particularised minutely enough, to enable us to estimate their value.

In order to judge of the correctness of these labours, we bring forward some examples. Thus, in the determinations of Lé in Ladak, the error which should be expected in the latitude would amount to 30″*. The longitude of Lé was determined by the transfer of one chronometer which was rated at Simla on the 15th May, at Lé on the 17th September, at Srinagar the 24th October; the longitudes of Simla and Srinagar are known. The rate of the chronometer should have been deduced from the longest transfer occupying 162 days, from which, in the main result, a considerable error was to be expected† amounting to no less than 7′.5. Further an error has crept into the calculations of the brothers Schlagintweit which, when corrected, will alter their result by 8′ (instead of 77° 14′ 6″ it should be 77° 22′ 5″ east of Greenwich). The correction of the chronometer was determined on the Karakoram pass on the 9th of August; by its action from Simla (15th May) to Srinagar (24th October) the longitude of the pass was determined at 77° 30′ 4″. But corrections of the chronometer at Lé were also obtained on the 11th July and 17th September, according to which the determinations of the Karakoram pass is found to be 77° 39′ 5″ or, otherwise, differing by 9′.

* The latitude of Lé was determined twice by polar heights.

11th July, ...	34° 7′5
16th September, ...	34° 9′2
Mean, ...	34° 8′3
According to Cunningham, ...	34° 9′1
" Moorcroft, ...	34° 9′3

† The chronometer was rated in the Observatory of Calcutta in March, 1855 and April, 1857 (pp. 98 and 102). From this it must appear, that the probable 24 hourly disturbance of the chronometer on the spot would not be less than ±s. In the longitude of Lé, also, one can suspect an error of at least $\frac{\pm s. \; 125.37}{162} = \pm$ 29s. From Simla to Lé is a journey of 125 days, from Lé to Srinagar 37 days; whole duration of the journey 162 days.

But the Schlagintweits express their doubts as to the correctness of the determination of time at Lé on the 11th July, and, therefore, do not take it into account. Nevertheless, an error of no less than 10′ must, in all probability, be suspected in the longitude of the Karakoram pass as well as in the longitude of Lē. It remains, consequently, open to doubt, which longitude is to be accepted, that given by the Schlagintweits, or that previously adopted by Humboldt, which Thompson, who visited this pass in 1848, found to be quite accurate. Up to this point, the corrections are less than $\frac{1}{2}^{\circ}$, and applied to the map attached to the description of their journey, they excite curiosity, but not surprise; but the upper portion of the map representing Central Asia puzzles every one, by its marked difference to every thing that has hitherto been known of these countries. It is sufficient to say that the position of the three bases of the cartography of this part of Asia, namely the towns of Khotan, Yarkand and Kashgar, disagrees with those hitherto generally accepted, by nearly 180 versts, for all the three points nearly equally lie 10′ in latitude, and 130′ in longitude, more southward and westward, according to the dictum of the Schlagintweits.

At the same time, the determinations of little Bokhara, which belong to the Jesuits, cannot call forth strong doubts; on the contrary, there is strong reason for believing, that if these determinations are not altogether correct, they are but very slightly incorrect. In Djungaria, there are several points determined by the Jesuits, and some subsequently by me in 1859. From a comparison of these determinations, it becomes evident that the latitudes given by the Jesuits are correct to a minute. But the astronomical observations in Djungaria were, in all probability, not made by the Jesuits themselves, but by Chinese whom they had instructed. It must therefore be supposed, that the points in little Bokhara, where the Jesuit fathers worked themselves, are equally correct. As regards the longitudes, it is well known that the existing itineraries coincide perfectly well with the determinations of the Jesuits, though it must be acknowledged that the marche-routes having almost a meridional direction, cannot point out any appreciable error in the longitudes. Generally speaking, the better acquainted we become with Chinese Turkestan, the more convinced we are of the accuracy of the determinations of the Jesuits.

In support of this, we shall here bring forward the following example. There are two routes, besides others, across the Tian Shan leading to little Bokhara; one from Kuldja to Aksu, the other from the southern shore of Lake Issyk-kul by way of the Faŭkŭ pass, to Ush. Until the astronomical labours of 1859, both these routes presented on the map considerable angles with the axis of the mountain range; the first one of nearly 45°, and the other that of 30°, but according to the astronomical results obtained in 1859, it was found that the inclination of routes from Kuldja to Aksu, to the axis of the range, did not exceed 30°, while the route to Ush intersects the ridge in a direct line, and runs north and south. It appears strange then after this, if, seeing the great inclination of the transverse routes to the axis of the mountains, that Issyk-kul, with the neighbouring countries on the northern side of the Tian Shan, had not been before removed to the west, as was done subsequently in consequence of the astronomical determinations; or that all the series of points in Little Bokhara were not removed to the east, and in every case not to the west. Facts like these, speak in favour of the positions of Ush and Asku, and other towns of Little Bokhara determined by the Jesuits; and it must be observed, that up to the present time no one has had the same means, as possessed by them, of determining the relative positions of these towns. The last point that the Schlagintweits determined instrumentally, is Suget, a halting place for caravans, proceeding from Ladak to Yarkand. This route is marked on a very rare map, which is a direct copy of an original one compiled by the Jesuits and translated by Klaproth; a point on this road under the same latitude with Suget, as determined by the Schlagintweits, has nearly one and the same longitude. Beyond Suget, all the other points on the Kuen-lun and in Turkestan, are determined by the marche-routes; the most northern of these and nearest to Khotan, which the two brothers Herman and Robert succeeded in reaching, is the village of Bashia. This point is also given on the map of the Jesuits, its position being fixed by marche-routes, not by direct determination. The difference in the positions of Bashia, as given by the Jesuits and the brothers Schlagintweit, amounts to 6′ in latitude, and 47′ in longitude. How is it then possible, after this, to accept the position of Khotan, and with it that of the other towns of Turkestan, as given by the Schlagintweits,

differing as it does by 130′ in longitude from the astronomical determinations of the Jesuits, when neither Herman nor Robert visited Khotan, while the papers of Adolph perished with him in Kashgar?

But how are we to regard the more recent labours in the country adjoining Little Bokhara, which cannot be reconciled to the points of the Schlagintweits?

Thus Sarry-Kul, the source of the Amu, which was determined by Wood, the Schlagintweits could not place on their map, according to the determination of Wood, but were obliged to remove it nearly 2° to the westward.

Issyk-kul is also marked on the map 2° more to the west than it should be, according to the last Russian astronomical determinations in 1859. And if this Lake be marked in its true position on the map of the Schlagintweits, Sarry-kul would then fall back on Yarkand, and the western extremity of Issyk-kul will appear above Asku, which, of course, would be impossible.

Petermann, in his notice of the labours and researches of the Schlagintweits, is of opinion that a review of their determinations in Little Bokhara is premature, more especially as the marche-routes by which they were guided, are not yet published. But the astronomical results of 1859, which so distinctly contradict the determinations of the Schlagintweits, belong to the Russian Geographical Society, and this is our excuse for expressing our doubts of the correctness of a certain portion of the results of the brothers Schlagintweit, before receiving the data on which they are based.

Comparative, hypsometrical and physical Tableau of High Asia, the Andes, and the Alps.—*By* Robert de Schlagintweit, *Professor at the University of Giessen.*

Contents.—I. *Geographical configurations.* 1. Plateaux. 2. Passes 3. Peaks.

II. *Hydrography.* 1. Lakes. 2. Springs.

III. *Physical phenomena.* 1. Snow-fall. 2. Snow-line. 3. Glaciers.

IV. *The varieties of habitation.* 1 Towns and villages. 2. Pasture grounds.

V. *Extreme heights visited by man.* 1. Mountain-ascents. 2. Balloon-ascents. 3. Effect of height.

VI. *Limits of vegetation and animal life.*

Remarks.—1. Drawings of many of the objects (plateaus, peaks, towns, &c.) mentioned in this Tableau, as well as panoramic profiles and maps, are contained in the Atlas to the "Results of a scientific mission to India and High Asia," by Hermann, Adolphe, and Robert de Schlagintweit.

2. The heights, given in English feet, are absolute, referring to mean sea-level.

Transcription.—Vowels and diphthongs sound as in Italian and German: ă = u in "but;" â = an in the French "gant;" ü = ü in German.—Consonants as in English. The sign ′ marks the syllable to be accentuated.

The materials, upon which this comparative tableau is based, are:

For *High Asia*, viz.—The Himálaya, Western Tibet, the Karakorúm and Künlün, our own travels and observations, combined with the valuable data of the Great Trigonometrical Survey of India, and with those of our predecessors.

For the *Andes*.—The celebrated "Voyages aux régions équinoctiales," by Alexander de Humboldt, which possess to this day the highest value and importance; in his recent publications,* the newest contributions of science have been added with a master's hand.

* Kosmos.—Ansichten der Natur, 3rd edition.—Kleinere Schriften.—I always quote the original, German edition.

For the *Alps.*—The two volumes "Untersuchungen über die physicalische Geographie und die Geologie der Alpen," published by my brothers Adolphe and Hermann.

I. Geographical Configurations.

1. *Plateaux.*

Plateaus, in consequence of their being more or less intersected by deep and broad valleys, or from being covered with ridges, are so variable in their form, that the use of the name, in many instances, appears to be somewhat arbitrary. I prefer not to extend the meaning of the name too far, and in so doing diverge from the practice of earlier travellers, who commonly applied the term to every mountainous region of great *general* elevations—as the natives of the Himálaya have a tendency to do—irrespective of its form.

In the *Himálaya*, which is composed in almost every direction of lofty and irregular ridges, and intersected by numerous valleys of inconsiderable width, no plateau of any extent has been discovered as yet, nor is it at all probable that one exists.

Western Tibet was for a long time supposed to be little else than a country of plateaux—an erroneous impression emanating from the first observers, though Humboldt had early pointed out the error of this belief,* as well as later travellers (the Stracheys, Cunningham, and Thomson). Plateaux certainly do occur in Tibet; they are, however, much less numerous and considerably smaller than I had been led to expect. In Bálti, the plateau Deosâi is 14,200 ft. high.

Between the *Karakorúm* and *Künlün*, especially near the western crest of the former, several well-defined plateaux of extraordinary height occur. Some of the highest are called: Dápsang (17,500 ft.), Búlli (16,883 ft.), Aksáe Chin (16,620 ft.), and Vohâb (16,419 ft.) In summer, no snow covers these plateaux, but also no vegetation: in the far distance there are some isolated, lofty, snowy peaks, besides which the eye discerns nothing but barren rocks, and extensive sterile plains, all well watered by streams, to which the glaciers covering the flanks of the peaks afford an ample and lasting supply. If water was wanting to these plateaux, they would be a complete desert, as uninhabitable to man as to any animal.

* Ansichten der Natur. Vol. I., p. 104.

In the *Andes* are to be found, if not the highest, at least the most extensive plateaux of our globe, which generally lie along the very ridge of the mountains, and on which large towns are situated, as Cerro de Pasco (14,098 ft.), Potosi (13,665 ft.), and Cuzco (11,380 ft.). There is also a large plateau surrounding the elevated lake Titicaca (12,843 ft.).

In the *Alps*, plateaux occur only at their base; the Swiss plateau having a mean height of 1,460 ft., the Suevo-Bavarian plateau of 1,420 ft.

2. *Passes.*

The mean of a sufficient number of such passes, which lead over the *principal crests*, is particularly to be taken into consideration, it being approximatively proportional, or, to express it more clearly, equal to the general mean height of these crests. The passes situate in the lateral ramifications of the principal crests—though they are numerous—cannot be included in these general means, being geographically of subordinate importance.

The mean height of passes in the three principal mountain-chains of *High Asia* is as follows:

A. *For the Himálaya* (mean of 19 passes,)...... 17,800 ft.

From Síkkim to Kishtvar: Bhután and Kashmír being excluded: the former for want of materials, and Kashmir on account of the Himalaya there losing the character of one well-defined and predominant chain.

B. *For the Karakorúm* (mean of 3 passes,)...18,700 ft.

From long. E. Gr. 76° to 79½°, the heights in the eastern continuation being quite unknown.

C. *For the Künlün* (mean of 2 passes,) .... 17,000 ft.

As the two passes are situated in parts not differing in any particular from the general mean of this chain, they may be looked upon as representatives of the other.

From these numbers it appears, that the Karakorúm has by far the greatest mean height of passes; but the one pass which we must still consider the highest, is situated in the Himálaya. This is the *Ibi Gámin pass* (20,459 ft.) leading from Gărhvál to Gnárí Khŏrsum, which my brother Adolphe and I myself crossed as the first, and as yet as the only Europeans, Aug. 22, 1855. The pass next in height

is the Mustágh pass in the Karakorúm chain (19,019 ft.), the third the Changchénmo, or Yéngi Daván (about 18,800 ft.), in the same chain. None of these passes are generally used as commercial roads. The highest pass as yet known to be regularly crossed with horses and sheep, for the purposes of commerce, is the Párang pass (18,500 ft.; Mr. Theobald, Jr. makes it 19,132 ft., which seems too high—); and between this height and 18,000 ft. are situated several of the most important and frequented passes, as the Mána (18,406 ft.) the Karakorúm (18,345 ft.) and the Kióbrang (18,313 ft.). The lowest passes in the Himálaya chain are the Shínku La (16,684 ft.) and the Bára Lácha (16,186 ft.); the well known Níti pass reaches 16,814 ft.

In the *Andes*, the general mean elevation of the passes is, according to Berghaus:

For the Western Andes, ... 14,500 ft.

For the Eastern Andes,.............................. 13,500 ft.

The highest passes are: Alto de Toledo (15,590 ft.), Lagunillas (15,590 ft.), and Assuay 15,526 ft.). The latter pass attains, according to Schmarda, only 14,517 ft.

In the *Alps*, the mean of the passes is .... 7,550 ft.

The highest pass, at least in former times not frequently used for commercial purposes, is the St. Théodule (11,001 ft.), upon which the brothers Platter have now erected a meteorological observatory.

3. *Peaks.*

In the beginning of this century, the Andes were supposed to contain the highest peaks on our globe, and Chimborazo to rise supreme above the rest. Though as early as 1816 this was proved by Captain Webb's measurements to be incorrect, yet some time elapsed, before the superiority of the *Himálaya* above the Andes was generally admitted. Now we know, from the valuable and accurate observations of the G. T. Survey of India, that Gaurisánkar, or Mount Everest (29,002 ft.) is the highest peak of the world. The memoir of Major J. T. Walker in the Journal of the Asiatic Society of Bengal, 1862, No. I., pp. 32—48, gives a detailed enumeration of the peaks hitherto measured in the Himálaya; this memoir, as well as the publications of Captain Montgomerie and private communications kindly received from the Surveyor General's Office, enable me to state, that 216 peaks are now accurately measured in the chain of the Himálaya. Among

these 216 peaks, 17 exceed the height of 25,000 ft., 40 the height of 23,000 ft., and 120 the height of 20,000 ft.

In the *Karakorúm*, peaks have lately been discovered, which are scarcely inferior in height to the loftiest in the Himálaya, though only its western part has as yet been explored. With regard to the heights of its eastern continuation, there is not enough known to allow even of an estimate being made.

The highest peaks of the Karakorúm are the Dápsang (Ko of the G. T. S. 28,278 ft.), the Diámar (26,629 ft.), and the Masheribrúm (25,625 ft.)

With reference to the *Künlün*, we can only mention the peaks that we saw and measured between the Yurungkásh pass and the western termination of this chain; our idea about the general height is the more limited, as we have not even itinerary reports of former travellers to assist us. None of the peaks seen there by ourselves exceeds 22,000 ft.

In the *Andes*, important alterations have very recently been made with reference to the succession of the peaks, when arranged according to height, and, even now, the same amount of accuracy cannot be ascribed to the hypsometrical determination of its principal peaks as to the trigonometrical operations in the Himálaya. The highest peak in the Andes is the Aconcagua (23,004 ft.) in Chili (Pissis gives only 22,451 ft.): and there are as many as five peaks higher than the Chimbarozo (21,422 ft.). In High Asia, forty-five peaks are known, which exceed in height the dominating peak of the Andes, the Aconcagua.

In the *Alps*, Mont Blanc (15,784 ft.) and Monte Rosa (15,223 ft.) are well known to be the highest peaks. Other high peaks are; Tăschhorn, or Lagerhorn (14,954 ft.), Weisshorn (14,813 ft.), Mont Cervin (14,787 ft.), and Dent Blanche (14,305 ft.).

II. Hydrography.

1. *Lakes.*

In the *Himálaya*, there are but very few lakes. That of Nainitál (6,520 ft.), in Kămáon, the Vúllar lake (5,126 ft.), and the Chinăr lake near Srinăgar in Kashmír, suffice to exhaust the category of those deserving mention.

Glacier lakes.—Accumulations of water formed by one glacier obstructing the outlet of a higher one—are of much more frequent occurrence. At times, the wall of ice breaks away before the pressure of the swollen waters, when the lower lands become suddenly inundated, and the torrent rushes on with uninterrupted violence for miles, exercising a marked influence even down to the lower parts of the river. Similar inundations, some of them of a most destructive character, have several times occurred. Two of the most elevated glacier-lakes are the Destál (17,745 ft.), in Gărhvál, and the Námtso, or Yúnám (15,570 ft.) in Lahōl.

Western Tíbet and Turkistán possess many lakes, all of which are situated in great heights; they are, however, gradually drying up, as becomes apparent by the unmistakeable marks of larger surfaces remaining from former times. They contain a greater quantity of salt than lakes in general, and most of them to an amount which renders them more or less brackish.

The following are the names and the heights of the principal :—

Lakes of Western Tíbet and Turkistán.

Aksáe Chin, ...	16,620	Níma Kar, ...	15,100
Tso Gyagár, ...	15,693	Háule, ...	14,600
Tso Kar, or Khauri Talán,	15,684	Tso Gam, ...	14,580
Múre Tso, ...	15,517	Tso Bul, ...	14,400
Kiúk-Kiŏl, ...	15,460	Tso Mithál, ...	14,167
Mansaráur, or Tso Mápan,	15,250	Upper Tsomognalarí, ...	14,050
Rákus Tál, or Tso Lánag,	15,250	Lower Tsomognalarí,... ...	14,010
Tsomoríri,...	*15,130		

In the *Andes*, the most remarkable lake is that of Titicaca (12,843 ft.)

The foot of the *Alps* is adorned with a great many lakes, all in low elevations of from 600 to 1,600 ft.

2. *Springs.*

Springs of an ordinary, mean temperature, commonly called cold springs, are of frequent occurrence in High Asia; the finest and most copious springs are to be found in *Kashmír*, as the spring Vérnag, Vétur Vúllar, Kókar Nag, Achibál, A'nat Nag and others. The spring Sónda Bréri, also in Kashmír, situate about five miles south-east of Shahabád, is the only intermittent spring as yet known in High Asia.

* According to Mr. Theobald, Jr. (see Journ. As. Soc., Beng., 1862, No. V., p. 513) only 14,272.

In *Western Tibet*, where rains in the higher parts are rare, and where the dryness in summer is so excessive that even the formation of dew is scarcely perceptible, cold springs are comparatively rare. In Turkistán, in Bálti, and Hasóra, we find a greater number of springs, a fact intimately connected with the general meteorological conditions of these provinces.

With reference to the limit, at which springs are to be found still in High Asia, I give the following data, derived from our own observations. The greatest height, at which we found a spring in the Himálaya, was 15,920 ft.; this spring was situated on the slopes of the Kyúngar pass. In Tibet, we discovered a real spring on the slopes of the Ibi Gămin peak still at a height of 17,650 ft.; this spring is probably the highest spring hitherto found.

As the highest spring in the Andes, Humboldt names the one called "Ladera de Cadlud," at a height of 15,526 ft. above the level of the sea; in the Alps, Adolphe and Hermann have found the highest cold spring at 10,440 ft.

Hot springs occur in High Asia in a surprisingly great number,* from the sea-level up to heights of more than 16,000 ft. The highest hot springs of High Asia are at Murgái, (16,382 ft.), in Núbia, at Momái (about 16,000 ft.), in Sikkim, at Púga (15,264 ft.), in Ladák, near the lake Aiúkkió (15,010 ft.), in Turkistán, and at Chagrár (about 15,000 ft.), in Pangkóng. As a curious and remarkable fact I may add, that the highest hot spring in India, at Hazaribágh, in Bengal, is only 1,750 ft. above the level of the sea.

The hottest spring of High Asia is at Manikărn (temp. 202° Faht.) in Kúlu (this is the hottest spring as yet found all over Asia), at Jămnótri (temp. 193° Faht.) in Gărhvál, and at Chorkónda (temp. 190° Faht.) in Bálti. The hottest springs of the world (if we exclude those, which rise in the immediate neighbourhood of volcanoes) are to be found in the Andes. There "Aguas de Comangillas," near Chichemequillo and Quanaxuato, at a height of about 6,200 ft., in latitude north 21°, show a temperature of 205°.3 Faht.;† and the springs "Las Trincheras" between Porto Cabello and Valencias, in

* See the "Enumeration of the hot springs of India and High Asia, given by me in As. Soc. Journal, 1864, No. I., p. 49.

† Humboldt's "Essai pratique sur la Nouvelle Espagne." 2nd Ed., Vol. III, (1827), p. 190.

Mexico, have increased, between the years 1806 and 1823, from 195° Faht. to 206°.6 Faht.,* thus exceeding at present the temperature of the "Aguas de Comangillas" by 1°.3 Faht.

The hottest known spring of Europe, unconnected with present volcanoes, is that of Chaudes Aigues in Auvergne (temp. 176° Faht.).†

III. Physical Phenomena.

1. *Snow-fall.*

The lowest height at which snow has fallen in the *Himálaya* during the winter, is about 2,500 ft., but such cases are extremely rare, having occurred in Kămdon and Gărhvál only twice (in 1817 and 1847), since the British took possession of the country.‡ Snow has fallen in the memory of man only once in Naháu§ (3,207 ft.), in the province of Simla. The snow, which falls once within several years in the Kángra valley, down to heights of 3,000 and 2,700 ft., disappears almost immediately. At Haribágh the snow melts away on the day it falls, or at least within thirty-six hours. During my travels in Kúlu, I was informed by the natives, as well as by several gentlemen who knew this part of the country thoroughly, that the village of Mándi (2,480 ft.), is below the limit of snow-fall.

At an elevation of 5,000 ft. scarcely one year passes by without snow-fall; but, even at this height, the snow disappears after a few days, and sometimes even hours. "It snows, but one does not see it," the natives of Kathmándu (4,354 ft.) very significantly use to say, meaning, that the rare nightly snow-falls are melted away by the earliest rays of the sun. 6,000 ft. may be assigned as the limit in the Himálaya, where snow regularly falls in winter, with the probability of remaining some time upon the ground.

In *Western Tibet* and in the *Karakorúm*, the general elevation of the country is so great, even in its lowest regions, that no part lies below the limit of hibernal snow-fall. But the quantity of snow actually falling is inconsiderable, and this circumstance it is, which forms one of the chief causes that the passes of the Karakorúm, even

* Humboldt's "Kosmos," Vol. IV., p. 246.
† Newbold, in "Philos. Transactions," 1845, p. 127.
‡ Colonel R. Strachey, in this Journal, Vol. XVIII., Part I., p. 309.
§ This Journal, Vol. III., p. 367.

the highest, remain open throughout the year. In some parts of Tibet the winter is the only season, when atmospheric precipitation at all takes place.

In the *Künlün*, even on its southern slopes, a greater amount of snow is precipitated than on the northern side of the Karakorúm, whilst its Turkistáni (northern) slopes differ still more from the Karakorúm in this respect, they being visited by very heavy rains and great snow-falls. Even at Káshgar (about 3,500 ft), in Turkistán, there are said to be several snowy days every winter.

The data, which I was able to collect on snow-fall in the *Andes*, are so few and vague, that I could not draw any conclusion from them. Also for the *Alps*, I could not bring forward any new facts with reference to the snow-fall.

2. *Snow-line.*

The snow-line, or the average height where snow remains perpetually throughout the year, has offered unexpected difficulties in its determination for the *Himálaya*. When Webb and Moorcroft first pointed out the general heights reached by the snow-line, when they first discovered the remarkable fact, that, in spite of the influence arising from exposition, the snow-line of the Himálaya descends lower on its *southern* (Indian) than on its *northern* (Tibetan) slopes, the statements of these travellers, now proved to be correct in all material points, were discredited by men of science both in Europe and in India. Humboldt, however, was among the first who endeavoured to remove the distrust with which these discoveries were received; he also gave an explanation* of the causes which were possibly sufficient to originate so remarkable a phenomenon as this of the unlooked-for differences existing between the snow-lines of the Tibetan and Indian slopes. He considers it "the results conjointly of the radiation of heat from the neighbouring elevated plains, the serenity of the sky, and the infrequent formation of snow in very cold and dry air." Of all these causes, however, the last is the most important. The direct insolation, being less interrupted on the Tibetan side, has also its share of influence; but the effect is comparatively small. As the best corroboration of the quantity of snow-fall being the principal cause of the depression on the southern (Indian) slope of the Himálaya, may

* "Asie Centrale," pp. 284, 327; "Kosmos;" Vol. I, p. 358.

be adduced the fact, that we found the isothermal lines for the year and the summer, which coincided with the snow-line on the Indian side, decidedly warmer than those on a level with the Tibetan snow-line. The fact, moreover, of the *Karakorúm*—though on an average three degrees farther north—having the snow-line so excessively high on both its slopes, offers another instance of the influence of limited precipitation.

In the *Künlün*, the meteorological conditions also become apparent in the different limits of the snow-line on either side; but here the effect is the reverse of that perceived in the Himálaya, the greater precipitation on the "northern" slopes (towards the plains of Turkistán) lowering the snow-line on that side to a considerable extent.

Although, in the Himálaya at large, the snow-limit of the Tibetan side does not descend so low as that of the Indian, yet the influence of exposition at once becomes apparent in the ordinary sense, corresponding to these latitudes, if we examine the slopes of a crest or mountain, of which, by the nature of its position, both slopes belong either to the Indian side of the ridge in general, or to the Tibetan side. The many and vehement disputes upon the much-discussed subject of snow-limits have chiefly arisen from the entire neglect of this modification.*

The values we obtain for the height of the snow-line on the three mountain chains of *High Asia* are:

			Feet.
A.	*Himálaya.*	Southern (Indian slopes), ...	16,200
		Northern (Tibetan) slopes, ...	17,400
B.	*Karakorúm.*	Southern (Tibetan) slopes, ...	19,400
		Northern (along the Turkistani plateaux),	18,600
C.	*Künlün.*	Southern (facing mountainous ramifications),	15,800
		Northern (facing the Turkistáni plain),† ...	15,100

For the *Andes*, the snow-limits are, according to Humboldt and Pentland:

* See Batten, in the "Calcutta Jour. of Nat. Hist.," Vol. IV. p. 537; Vol. V. p. 383. Capt. T. Hutton, "in the same Journ." Vol. IV. p. 275; Vol. V. p. 379; Vol. VI. p. 56; and Capt. A. Jack, "in the same Journ." Vol. IV. p. 455.

† "Asie Centrale," 1847, Vol. II. pp. 165 and 177.

	Feet.
Eastern Andes of Bolivia, ...	15,900
Western Andes of Bolivia, ...	18,500
Andes of Quito, ...	15,700

For the *Alps*, my brothers obtained :

Southern slopes, ...	9,200
Northern slopes, ...	8,900
Extremes (near the Mont Blanc and Monte Rosa group), ...	9,800

3. *Glaciers.*

The existence of the glaciers of High Asia was first made known for *Western Tibet*, by Vigne, who alludes to them repeatedly in his "Travels in Kashmír," London, 1842. Colonel Richard Strachey was the first* who (in 1847) proved their existence in the *Himálaya.* The recent date of this discovery will appear the more surprising, when the immense number of glaciers now positively ascertained to be in this region is taken into consideration. The great amount of ice to be met with, even in lower elevations of the Himálaya, could not of course escape the observation of previous travellers; these masses, however, they used to designate as "hard, frozen snow-beds," and to consider them as local phenomena, analogous to remains of avalanches.

On both sides of the Karakorúm and the Künlün, we also found glaciers, having forms identical with those of the Alps, and following the same laws of motion. Some of them are considerably larger than the glaciers in Europe. The Aletsch glacier in the Alps extends a little over fifteen miles in length, whilst some of the glaciers, surveyed by Captain Montgomerie and his party in Bálti (on the southern side of the Karakorúm)" boast of no less than thirty-six miles in length, with a breadth of from one to two and a half miles. The Biáfo glacier forms, with the glacier on the opposite slope towards Miggáir, a continuous river of ice of sixty-four miles running in an almost straight line, and without any break in its continuity beyond those of the ordinary crevasses of glaciers. The Biáfo glacier is supplied in a great measure from a vast dome of ice and snow, about one hundred and eighty square miles in area, in the whole of which only a few projecting points of wall are visible. The Bálsoro main glacier, thirty-

* See this Journal, Vol. XVI., part II. p. 794; Vol. XVII. part II. p. 203.

six miles in length, and with fourteen large tributary glaciers of from three to ten miles in length, would form a study in itself, and give employment for several summers, before it could be properly examined."*

In the *Himálaya*, the lowest glaciers go down to 11,000 ft. and even 10,500 ft.; the Píndari ending at 11,492 ft., the Timtimna at 11,430 ft., the Tsóji at 10,967 ft., and the Chàia at 10,520 ft.

In *Western Tibet*, they descend to about the same elevation; thus, the Mustágh 11,576 ft., the Tapto 11,508 ft., the Támi Chúet to 10,460 ft., the Bépho (Biáfo of Capt. Montgomerie?), near Askoli, even to 9,876 ft. The latter is worthy of notice as a remarkable case of low termination.

In the *Künlün*, the glaciers end probably at heights not much differing from those in Western Tibet; at least so we infer from the general appearance of the upper part of the glaciers we saw during our travels in these regions. The glaciers on both flanks of the Elchi pass presented, however, no instances of particularly deep descent.

In the *Andes*, no glaciers are as yet known to exist,† and they do not occur in tropical America, from the equator to 19° latitude north.

In the *Alps*, the lowest glacier is that of Lower Grindelwald, ending at 3,290 ft, but in general 5,000 ft. must be considered as a rather low end of a glacier.

IV. The Varieties of Habitation.

1. *Towns and Villages.*

The *Himálaya* rises, in general, so abruptly above the plains of India, and the latter, particularly in the western regions, are in themselves of such an elevation, that even in the lower parts of the valleys there are but few, if any points of less height than 1,000 ft. above the level of the sea. Two causes more especially have tended to displace the order of population in these districts, the lower parts being almost deserted in favour of the lands lying immediately above. In the first instance, the prevailing steepness of the country hereabouts, which is still considerably increased by the erosion of the rivers, precludes the successful cultivation of the soil; and, again, the fertile, well cultiva-

* Montgomerie, in "Journ. As. Soc. Beng. 1862, No. II. p. 210.
† Humboldt, "Asie Centrale," Vol. II. p. 167.

ted plains of India are converted, wherever they touch the southern foot of the Himálaya, into swampy and marshy lands, called the Tarái, which in some parts form but a narrow strip or belt, whilst in others, as in Nepál, they attain a breadth of thirty to forty miles. The Tarái abounds with large and lofty forest trees. Owing to the swampy and malarious character of the Tarái, which skirts the extremities of the valleys, the neighbourhood is rendered as uninhabitable to the tribes of the Central Himálaya as to the highly susceptible and less seasoned visitor from European climes. Consequently (from all these reasons stated), in the inferior stratum of heights, ranging between 2,000 and 3,000 ft., the number of places inhabited by the natives is comparatively insignificant; while population reaches its maximum in the rich belt of life rising from 5,000 to 8,000 ft., the traces of man and his dwelling-place begin rapidly to disappear at 11,000 ft., and even before.

The *highest limits of habitation*, however, very often present themselves under a form which almost excludes the possibility of strictly comparing them as dependent upon climate. It is a remarkable fact, that in some provinces of the Himálaya, especially in Nepál, Kămáon, and Gărhvál, many villages are deserted in winter, though as far as regards their elevation and the solid construction of the houses, they might very well be inhabited throughout the year. The natives, however, prefer removing to villages less elevated, where they spend the colder months. In the Himálaya west of Gărhvál, such modifications do not occur; at least we are not aware of the existence of villages in Simla, Kúlu, Kishtvár &c., where the inhabitants follow regularly the nomadic example furnished in other parts of the hill country.

The Alps of Europe also present instances of this kind in Findelen (7,192 ft.), Bresily (6,594 ft.), and many other summer villages of greater or less elevation on the French side of the Alps.

Western Tibet is a country of such general elevation, that only in the province of Bálti villages are to be found below a height of 6,000 ft. Some of the chief towns are built at considerable elevations; Leh, the capital of Ladák, lies 11,527 ft. above the level of the sea. The *highest permanently* inhabited places are, however, Buddhist monasteries, the most elevated being probably that of Hánle, (15,117 ft.), in Ladák. I state it positively as my conviction, that nowhere in

the world there exists a permanently inhabited place at a height exceeding 15,600 ft. Paul de Carmoy's "Pueblo de Ocoruro," in the Sierra Nevada, 18,454 ft. high, will prove, on a closer examination, to be a temporarily inhabited place, similar to the *summer villages* of Tibet, of which I name Gártok (15,090 ft.), Nórbu (15,946 ft.), and Púga (15,264 ft.)

In the *Kiúnlün*, even the foot of its southern (Tibetan) slopes is so elevated, that no villages exist at all. By combining with our own observations a variety of reports received, I obtain for its northern slopes 9,400 ft. as the limit of permanently inhabited villages; summer villages reach about 10,200 ft.

In the *Andes*, large and important permanently inhabited places have been built at great heights (Cerro de Pasco, 14,098 ft., Potosi 13,665 ft.); they are generally situated on plateaux. Santa Barbara, a mine with solid houses, about three miles south of Huancavelica, is situated at a height of 14,508 ft.

For the *Alps*, I have already had occasion to mention their summer villages. The highest permanently inhabited villages are in the valley of Avers in Graubündten, where Juf lies at an elevation of 7,172 ft., and that of Cresta exceeds 6,700 ft. But the roads leading across the passes have rendered it necessary to construct houses near the top which are permanently inhabited; the highest of these at present being the well known monastery of St. Bernard (8,114 ft.) As long as the road over the Stelvio or Stilfser Joch was kept up, Santa Maria (8,146 ft.) was also inhabited throughout the year.

2. *Pasture-grounds.*

In the *Himálaya*, pasture-grounds "Kărik," for sheep and bovine cattle, are for the most part in low elevations, and at no great distance from the villages. The Kărik Biterguár, in Kămáon, must be mentioned as an exception to this general rule, it being situated at an elevation of 14,594 ft. Nowhere are there built on these pasture-grounds châlets (Alpenhütten), which are as little used in the Himálaya as tents in the Alps.

Dairies, which are dispersed all over the Alps, and which form the source of a profitable income under an able management, are quite unknown in the Himálaya, even in those parts, as Kashmír and Nepál,

where ample tracts exist extremely favourable for erecting such establishments even on a large scale.

The pasture-grounds of *Tibet*, to which the numerous herds of sheep are driven in summer, reach an elevation from 15,000 to 16,349 ft., beyond which the Tibetan shepherds, who sometimes remain upon the mountains from June to September, cannot be supposed to make any permanent residence. The most elevated pasture-grounds of Tibet are, Lársa (16,349 ft.), Zinchín (16,222 ft.), Kyángchu (15,781 ft.), Rúkchin (15,064 ft.), Ámlung (15,300 ft.), and Júgta (15,058 ft.)

Though many cloudless days succeed each other in these lofty regions, thus leaving the power of direct insolation unimpaired, the climate always remains bleak; while the prevailing winds not only aggravate the effects of a low temperature, but also that of a low barometrical pressure, thus presenting a remarkable modification of climate, of which I shall hereafter give some detail in the considerations upon the influence of height in general. The shepherds with difficulty provide themselves with a sufficient supply of fuel for cooking purposes; sometimes they contrive with much labour and pains to erect rude stone walls, behind which they may take shelter during the night. These walls are usually circular in form, from four to five feet high, and without a roof.

In the *Künlün*, the slopes on its southern side are so elevated, that there exist no pasture-grounds at all; on its northern slopes, they do not occur above 13,000 ft.

For the *Andes* no data with reference to pasture-grounds are at my disposal.

The pasture-grounds in the *Alps*, which are generally in the neighbourhood of Châlets, may be met with at heights of 8,000 ft. and upwards: the Fluhalpe (8,468 ft.) on the Findelen glacier near the Monte Rosa, and the Torrenthütle, in the Anniviers valley, being instances of the greatest elevations.

V. Extreme heights visited by man.

1. *Mountain-ascents.*

Temporary habitations, frequented for some months, as we have seen from the discussion of the highest pasture-grounds, sometimes reach a height of nearly 16,300 ft. As far as my experience goes, I

may state, that for short periods of ten or twelve days, man may considerably exceed this height, not without suffering, but at least without positive injury to himself. During our explorations of the Ibi Gámin glaciers, August 13th to 23rd, 1855, we encamped and slept during these ten days in company with eight men at very unusual heights. During this period, our lowest camp was pitched at 19,326 ft.—the greatest height at which we ever passed a night: — another was at 19,094 ft.; two camps exceeded 18,300 ft., and the remainder ranged between 18,000 and 17,000 ft. Apart from the extreme elevation and consequent cold, the bodily exertions imposed upon us during our stay, proved a great tax upon our powers. Once we crossed a pass of 20,439 ft., and three days earlier, August 19th, 1855, we had ascended the flanks of Ibi Gámin to a height of 22,259 ft. This, as far as we know, is the greatest height yet reached on any mountain, though considerably below that to which man has arisen in balloons.

On the Sássar peak we attained (August 3rd, 1856) an elevation of 20,120 ft. As early as 1818, however, the brothers Alexander and James G. Gerard ascended (October 18th) a peak in Spiti 19,411 ft. high, not far from the Porgyál, or Tazhigáng. Subsequently, August 31st, 1828, Dr. James G. Gerard reached 20,400 ft.

From Captain T. G. Montgomerie we learn, that a station of 19,979 ft. has been reached twice by Mr. W. H. Johnson, and another of 19,958 ft.* in height by Mr. W. G. Beverley. Mr. Johnson took, besides, observations in Ladák at one station more than 20,600 ft. high, the greatest altitude yet attained as a station of the Trigonometrical Survey of India.† A trigonometrical mark has even been erected on a point 21,480 ft. above the level of the sea, "but unfortunately there was not sufficient space to put a theodolite on it."

In the *Andes*, Humboldt ascended the flanks of Chimborazo (June 23rd, 1802) to a height of 19,286 ft.; this being the extreme elevation attained at that period. Some years afterwards (December 16th, 1831), Boussingault reached, on the same peak, a height of 19,695 ft.‡

In the *Alps*, my brothers Adolphe and Hermann once remained in the Vincenthütte, on the slopes of Monte Rosa, fourteen days at a

* See this Journal, 1861, No. II., pp. 99, 110.
† See this Journal, 1863, No. II., p. iii.
‡ Humboldt's "Kleinere Schriften," p. 157.

height of 10,374 ft. The well known English Professors Tyndall and Frankland even passed the night of August 21st, 1859, on the top of the Mont Blanc (15,784 ft.)

2. *Balloon-ascents.*

In the free atmosphere the greatest height was reached by Mr. Glaisher in a balloon, which was directed by Mr. Coswell; he ascended, September 5th, 1862, the extraordinary height of at least 30,000 ft., but, as he was unable to make any observations above that height, being suddenly overtaken by sickness, it is supposed that the balloon rose as high as seven miles = 36,960 ft.

Not less remarkable than this ascent was the one performed by Gay-Lussac, as early as the beginning of this century (September 16th, 1804), when he rose to 23,020 ft. Between Gay-Lussac's and Mr. Glaisher's ascent, several attempts have been made to reach great heights in balloons, especially in England, during one of which the late Mr. Welsh reached (November 10th, 1852) 22,930 ft.* The balloon-ascents made in England were all combined with experiments of a highly interesting nature, and instituted by a scientific committee, among whose members it is sufficient only to name Sabine and Sykes.

Previous to Mr. Welsh, Messrs. Bixio and Barral rose (July 27th, 1850) to a height of 23,009 ft.

As a balloon-ascent, remarkable not only on account of the height reached, but on account of the horizontal distance performed, I must mention the one made by Mr. Nadar, in company with eight persons, October 18th, 1863. Mr. Nadar rose from Paris and let himself down —or he rather fell down—near Rethem, a small town on the river Aller, in Hanover. The direct distance between these two towns is about 395 miles, and as it took 15 hours, 47 minutes to travel through this distance, the balloon flew 2,227 ft. per minute, or 37 ft. per second. But, as the balloon was far from going in a straight line, it has been computed, that the greatest velocity attained by it amounted to 50 ft. per second.

3. *Effect of height.*

The effect of height is chiefly perceptible in the decrease of temperature and barometrical pressure. According to our observations,

* "Philosophical Transactions," 1853, Part III., p. 320.

the atmospheric pressure is, at a height of about 18,600 or 18,800 ft., one-half of that at the level of the sea. At an elevation of 22,200 ft. (so trivial a height when compared with the extreme upper limit of the atmosphere), we observed a barometrical pressure of 13.364 inches, so that nearly three-fifths of the weight of the atmosphere lay below the point reached by us at the time.

It is evident that there must be a limit beyond which the degree of rarefaction is incompatible with the conditions of human existence; but it will ever remain extremely difficult to determine the line of demarcation, with any approach to scientific precision.

The influence* which height exercises upon man, varies with the individual; a man in good health having the chance of less suffering. The difference of race has apparently no appreciable importance. Our Hindu servants suffered far more from the cold than our Tibetan companions, though not more from the diminished pressure. For the generality of people the influence of height begins at 16,500 ft., a height nearly coinciding with that of the highest pasture grounds visited by shepherds.

The complaints produced by diminished pressure are,—headache, difficulty of respiration, and affection of the lungs, the latter even proceeding so far as to occasion blood-spitting, want of appetite and even sickness, muscular weakness, and a general depression and lowness of spirits. Bleeding of the nose we experienced ourselves, though very rarely, the loss of blood on such occasions being insignificant; but bleeding of the ears and lips we neither experienced personally, nor observed in others during our travels in *High Asia.* Humboldt,† however, states, that on the Antisana, at a height of 18,141 ft., his companion, Don Carlos Montufar, bleeded heavily from the lips, and that during the ascent of the Chimborazo, every one suffered from bleeding of the lips and even the gums.

The effects here mentioned, which disappear in a healthy man almost simultaneously with his return to lower regions, are not sensibly increased by cold, but the wind has a most decided influence for

* Notices and remarks on this subject are to be found in "Gleanings in Science," Vol. I., p. 330; Gerard's "Koonawur;" Hooker's "Himalayan Journals," Vol. II., p. 413; Thomson's "Western Himálaya and Tibet," p. 135 and p. 483.

† "Kleinere Schriften," Vol. I., p. 148.

the worse upon the feelings. As this was a phenomenon we had not hitherto found mentioned by former observers, we directed our particular attention to it, and remarked instances where fatigue had absolutely nothing to do with it. In the plateaux of the Karakorúm, it was a common occurrence, even for the sleepers in the tents, where they might be considered as somewhat protected, to be waked up in the night with a heavy feeling of oppression, the entire disturbance being traceable to a breeze, which had sprung up during the hours of rest.

The effects of diminished atmospheric pressure are considerably aggravated by fatigue. It is surprising to what a degree it is possible for exhaustion to supervene; even the act of speaking is felt to be a labour, and one gets as careless of comfort as of danger.

VI. Limits of vegetation and animal life.

1. *Vegetation.*

In *India*, the vegetation is not limited by climate in the elevations existing; the highest peaks, as the Dodabétta (8,640 ft.), in the Nilgiris, the most elevated plateaux are covered with trees, shrubs, and in fact a luxurious vegetation, not only along their slopes, but even on their top.

In the *Himálaya*, trees grow very generally up to heights of 11,800 ft., and in most parts there are extensive forests covering the sides of the mountains at but a little distance below this limit. Those forests are especially beautiful in the higher valleys of Kâmáon and Gârhvál, in the Bhagiráthi valley.

In *Western Tíbet*, though we did traverse it in various directions, none of us found anything at all corresponding to a forest. Apricot trees, willows, and poplars are frequently cultivated on a large scale; poplars, indeed, are found at Mángnang, in Gnári Khórsum, still at a height of 13,457 ft.; but they are the objects of the greatest care and attention to the Lamas.

In the *Künlün*, we found the trees on its northern side not to grow above 9,100 ft. On the northern side, we saw no trees at all; here the considerable height of the valleys we passed excluded them.

In the *Andes*, trees end at about 12,130 ft.; in the *Alps* on an average at 6,400 ft., isolated specimens occurring, however, above 7,000 ft.

The cultivation of grain coincides, in most cases, with the highest permanently inhabited villages: but the extremes of cultivated grain remain below the limit of permanent habitation. In the *Himálaya*, cultivation of grain does not exceed 11,800 ft., in *Tibet* 14,700 ft., and in the *Kiúnlün* 9,700 ft. For the *Andes*, the limit is 11,800 ft.; in the *Alps*, some of the extremes are found near Tindelen, at a height of 6,630 ft., but the mean is about 5,000 ft.

The upper mean limit of grass-vegetation is, in the *Himálaya*, at 15,400 ft., in *Western Tibet* at 16,500 ft.; in the *Künlün*, grass is not found above 14,800 ft.

Shrubs grow, in the *Himálaya*, up to 15,200 ft., in *Western Tibet*, as high as 17,000 ft. On the plateaux to the north of the *Karakorúm*, shrubs are found at 16,900 ft., and, which is more remarkable, they occasionally grow there in considerable quantities on spots entirely destitute of grass. As an example, I mention the Voháb Chilgáne plateau (16,419 ft.) and Bashmalgún (14,207 ft.)

In the *Künlün*, the upper limit of shrubs does not exceed 12,700 ft.; above this height grass is still plentiful; and shrubs being here, as generally everywhere else, confined to a limit below the vegetation of grass, the range presents an essential contrast in this respect to the characteristic aspect of the Karakorúm.

In the *Andes*, shrubs grow up to 13,420 ft, in the *Alps*, their upper limit is at 8,000 ft.

The very extreme limit of phanerogamic plants appeared in *Tibet* at the north-eastern slopes of the Ibi Gămin pass, at a height of 19,809 ft.; next in order came those of the Gunshankăr peak, in Gnári Khórsum, at 19,237 ft. In the *Himálaya*, the highest plants were found by us at 17,500 ft., on the slopes of the Jánte pass, in Kămáon.

In the *Andes*, Colonel Hall found the highest phanerogamic plants on the slopes of Chimborazo, at 15,769 ft., consequently 4,040 ft. lower than the Ibi Gămin plants in Tibet.

In the *Alps*, my brothers found an analogous extreme on the southern slopes of the Vincent pyramide at 12,540 ft.

2. *Animal life.*

Monkeys appear to frequent, in the Himálaya, regions exceeding 11,000 ft. in height; the ***Semnopithecus schistaceus***, Hodgs. ascending

higher than others. These monkeys, called "Langúrs" by the natives, have been frequently seen at 11,000 ft., while the fir-trees among which they sported were loaded with snow-wreaths. This species is not known in India, whilst the Macacus Rhesus is met with in India, as well as in the Himálaya.

In *Western Tibet*, and farther to the north, no monkeys have yet been found. *Tigers* ascend to 11,000 ft. in the Himálaya; they are not, however, seen in Western Tíbet or the Künlün.

Leopards may be met with, in the Himálaya and in Tíbet, even at 13,000 and 14,000 ft. The *lion*, though intimately connected with the mythology of High Asia, has been forthcoming, in historical times, only in Kashmír. In India, the lion occurs at the present day only in Guzrāt, and there only in very small numbers.

Jackals were found by us in the Karakorúm between 16,000 and 17,000 ft. *Wolves* are not known to frequent the Himálaya Proper, but they are found in Tibet, where we saw of traces of them in sand close to the Karakorúm pass (18,345 ft.)

Various species of beautiful *wild sheep* and *ibex*, together with the *Kyáng* and the *wild yak*, are met with in large herds on the highest plateaux between the Karakorúm and the Künlün.

The *cat* is common in Tibet; *dogs* are the companions of the Tibetan shepherds, whom they follow over passes exceeding 18,000 ft.

Some species of *bats* are seen in the Himálaya up to 9,000 ft.; and the Tibetan *hare* occurs even in heights exceeding 18,000 ft.

Migratory birds are not known to cross the Himálaya, as many birds of Europe cross the Alps. *Doves* were seen by us at very great heights in the Karakorúm and Künlün; this was the most surprising, as other birds were very rare.

The domestic *fowl* has recently been introduced with great success by Guláb Singh into Bálti, Ladák, and Núbra.

Fishes were found by us in some rivulets of Tibet exceeding 15,000 ft. In the *Alps* they cannot live beyond 7,000 ft.

Of *reptiles* we found snakes and saurians as high as 15,200 ft. In the *Alps* they go up to 6,000 ft., in the *Pyrenees* to 7,000 ft. In the *Andes*, snakes were found by Schmarda at about 11,500 ft.

For *butterflies* we found in the Himálaya 13,000 ft., in Tibet and Turkistán even 16,000 ft. as localities of permanent habitation. *Bee-*

tles probably follow the highest formation of grassy turf in the Himálaya, as well as in the Andes and the Alps. *Mosquitoes* go up to 8,500 ft.; and *peepsies* make themselves very troublesome during the rainy season as high as 13,000 ft.

The existence of *infusoria* seems as little subject to limitation by height in High Asia, as in the Andes and Alps. In a few fragments which we chipped off from the rocks of the Ibi Gamin pass (20,459 ft.) Prof. Ehrenberg of Berlin detected their presence, and found them not insignificant in quantity; he discovered twelve species new to science.

(*Notes and Queries.*)

[Received 20th December, 1865.]

Camp, near Myanoung, November 22nd, 1865.

During a visit to Calcutta a few months ago, Mr. Grote drew my attention to a sort of controversy which had been started at home, touching the habit, which fireflies were stated to exhibit occasionally, of a concurrent exhibition of their light, by vast multitudes acting in unison; a statement which appeared to have been somewhat sceptically received. Mr. Grote does not appear to have ever witnessed this phenomenon in Bengal, and questioned me if I had ever observed any confirmatory instance. Fireflies are tolerably well known, of course, to the resident in Bengal, but I had never there observed any such habit among the countless fireflies, which form such fiery-like ornaments to the shrubberies about Calcutta. In Pegu, however, I have witnessed the exhibition in question; myriads of fireflies emitting their light, and again relapsing into darkness, in the most perfect rythmic unison. I much regret, that I did not secure specimens, but the circumstances were as follows. I had halted my boat for the night, alongside a small clearing in the low lying tract of country, forming part of the Irawadi estuary (Delta), east of the Bassein river, where the water was salt, and the entire country not more than a foot, if so much, above the flood level. Night had closed in, and my servant, who brought in the tea, asked me to step out of my tent and see the fireflies which, he said, he had never seen the like of before. On stepping out of the tent, a truly beautiful sight presented itself. In front was the broad and deep river sweeping on, νυκτὶ ἐοικώς, with its indistinctly seen background of primæval forest on its opposite bank. Around me was the recently-formed clearing, with its two or three huts and my own camp, as the sole proof of man's occupancy, for miles and miles, but, for all the wildness and almost desolation of the scene, the bank on which I stood was a glorious spectacle, and those acquainted with the class of native servants will well understand that it must have been at once unusual and beautiful indeed to rivet the attention of a listless khitmutgar!

The bushes overhanging the water were one mass of fireflies, though, from the confined space available for them on low shrubs, the

numbers may not have been actually more than are often congregated in Bengal. The light of this great body of insects was given out as I have said, in rythmic flashes, and, for a second or two, lighted up the bushes in a beautiful manner; heightened, no doubt, by the sudden relapse into darkness which followed each flash. These are the facts of the case (and I may add, it was towards the end of the year), and the only suggestion I would throw out, to account for the unusual method of luminous emanation, is, that the close congregation of large numbers of insects, from the small space afforded them by the bushes in question, may have given rise to the synchronous emission of the flash, by the force of imitation or *sympathy.*

Mr. Montgomery, of the Survey Department here, also fully corroborates the habit of our Pegu fireflies simultaneously emitting their light, but adds, he has only remarked it under conditions similar to those described above, in low swampy ground. It still remains, therefore, to be decided if the insect is different from the ordinary one, or if, as I am inclined to think, the simultaneity is produced by sympathy and great crowding of individuals.

Whilst my pen is in my hand, I would add a few words on the address of Dr. J. E. Gray to the Zoological Section of the British Association, printed at page 75 of the Notices and Abstracts appended to the Report of the Association for 1864.

The excellent remarks on the aim and arrangement of Public Museums will, it is to be hoped, not escape the attention of those interested in our own Calcutta Museum, and the especial stress he lays on the exclusion of light from collections on spirits, is what I urgently brought to the notice of the Society but a short time since. It is not, however, to this portion of Dr. Gray's address that I would now refer, but to the statement at page 82 that, "*the natives of India and of the islands of the Malayan Archipelago have brought into a semi-domesticated state various species of wild cattle, such as the Gyal, the Gour, and the Banteng.*"

Of the first of these, the Gyal, we know that such is the case, but I should much like to know in what part of India or Malaynesia the *Gour* or the *Banteng* are "semi-domesticated," certainly, the feat has never been performed by any "*native of India,*" of whose geography and powers incurably lax notions appear to be stereotyped in England,

from the ablest downwards. I would enquire, therefore, through the pages of this Journal, to what instances Dr. Gray can allude, as the fact is certainly novel to those in India. The Governor of Rangoon, at the time of the last war, I am told, had a pair of Gour sufficiently tame to be yoked in a cart, but this is quite insufficient to establish their claim to be viewed as semi-domesticated. In India, the difficulty of rearing the calves is notorious.

Again, immediately before the passage I have quoted above, Dr. Gray remarks, "In the lower and warmer region of Central and Southern Asia, *the Zebra* has been completely domesticated."

In the passage, Dr. Gray is alluding to wild species brought by man into a state of domestication, and I confess to some curiosity as to the wild stock of the domesticated Zebra. There is, I fancy, some little confusion, however, in Dr. Gray's ideas here, as, on the previous page, he tells us, "the oxen" "are never found *truly wild.*"

The distinction, too, which Dr. Gray draws (loc. cit.) between the "*truly domesticated*" animals, the ox, the sheep, the horse, the camel, the dog and the cat, and the "*semi-domesticated,*" as the buffalo, the goat, the pig, the rabbit, the reindeer, the yak &c., appears forced and to a great extent imaginary.

The distinction between these two classes of animals is more due to the efforts of the *Breeder* than to *mere domestication*, and I should have thought, that the highest triumphs of some of our rabbit fancies and of our breeds of pigs merited quite as much as our "sheep" to be considered as "truly domesticated," if thereby is intended an unnatural deviation from the wild stock, solely produced by the art of the Breeder.

I cannot enter at greater length on this most interesting question, but I hope that some of the readers of this Journal who have perused Dr. Gray's report, will be able to furnish some explanation of the points indicated above.

Another query I would ask is, to what *race* of *Calotes mystaceus* can Gunther refer to, when he states that "an old male measures nearly 24 inches, the tail taking 19 inches?" Now *Calotes mystaceus* is *common in Birma*, and more than a score have passed through my hands, but no specimen that I ever saw attained to even 12 inches of total length!

Are not two races or species here united, a smaller one from Birma, and a larger one from Camboja or elsewhere south?

The type in the Paris Museum, Gunther says, is "not full grown," but it was from Birma, and is probably the size of ordinary Birmese specimens.

W. Theobald, Jr.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of August, 1865.

Latitude 22° 33′ 1″ North. Longitude 88° 20′ 34″ East.

Height of the Cistern of the Standard Barometer above the Sea-level, 18 ft. 11 in.

Daily Means, &c. of the Observations and of the Hygrometrical elements dependent thereon.

Date.	Mean Height of the Barometer at 32° Faht.	Range of the Barometer during the day. Max.	Min.	Diff.	Mean Dry Bulb Thermometer.	Range of the Temperature during the day. Max.	Min.	Diff.
	Inches.	Inches.	Inches.	Inches.	o	o	o	o
1	29.647	29.705	29.577	0.128	83.0	87.2	79.8	7.4
2	.689	.766	.627	.139	81.3	84.9	77.2	7.7
3	.712	.773	.640	.133	83.3	89.4	79.7	9.7
4	.701	.761	.629	.132	84.6	89.4	80.8	8.6
5	.700	.745	.631	.114	86.0	92.6	81.4	11.2
6	.688	.746	.617	.129	84.6	89.0	82.0	7.0
7	.711	.764	.656	.108	84.5	89.0	80.0	9.0
8	.700	.767	.613	.154	85.8	90.8	82.0	8.8
9	.665	.725	.590	.135	85.5	90.2	81.7	8.5
10	.646	.692	.587	.105	86.6	91.5	82.4	9.1
11	.678	.722	.635	.087	85.4	90.6	82.6	8.0
12	.718	.770	.656	.114	86.3	92.2	81.8	10.4
13	.719	.762	.654	.108	86.1	92.1	82.4	9.7
14	.675	.727	.593	.134	85.9	91.4	82.3	9.1
15	.666	.752	.610	.142	85.4	90.8	81.6	9.2
16	.724	.771	.678	.093	83.4	89.0	80.8	8.2
17	.733	.779	.672	.107	83.8	87.9	80.6	7.3
18	.638	.724	.543	.181	84.5	92.1	81.2	10.9
19	.538	.606	.447	.159	84.8	91.4	81.7	9.7
20	.488	.539	.400	.139	85.1	90.8	81.4	9.4
21	.419	.494	.330	.164	83.3	87.0	80.8	6.2
22	.448	.553	.388	.165	82.6	86.2	80.2	6.0
23	.568	.622	.524	.098	84.4	91.0	80.4	10.6
24	.584	.636	.511	.125	85.1	90.8	81.0	9.8
25	.568	.608	.505	.103	84.6	89.2	81.6	7.6
26	.532	.593	.468	.125	85.4	92.6	81.6	11.0
27	.470	.540	.380	.160	84.7	89.8	82.2	7.6
28	.439	.591	.311	.280	81.2	84.4	79.0	5.4
29	.634	.685	.583	.102	82.5	85.5	80.2	5.3
30	.624	.690	.548	.142	85.1	90.0	81.2	8.8
31	.591	.640	.532	.108	85.6	90.6	81.4	9.2

The Mean Height of the Barometer, as likewise the Dry and Wet Bulb Thermometer Means are derived from the hourly Observations made during the day.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of August, 1865.

Daily Means, &c. of the Observations and of the Hygrometrical elements dependent thereon.—*(Continued.)*

Date.	Mean Wet Bulb Thermometer.	Dry Bulb above Wet.	Computed Dew Point.	Dry Bulb above Dew Point.	Mean Elastic force of Vapour.	Mean Weight of Vapour in a Cubic foot of air.	Additional Weight of Vapour required for complete saturation.	Mean degree of Humidity, complete saturation being unity.
	o	o	o	o	Inches.	T. gr.	T. gr.	
1	80.8	2.2	79.3	3.7	0.979	10.51	1.31	0.89
2	79.2	2.1	77.7	3.6	.931	.02	.22	.89
3	80.2	3.1	78.0	5.3	.940	.09	.84	.85
4	81.1	3.5	78.6	6.0	.958	.26	2.13	.83
5	82.0	4.0	79.2	6.8	.976	.41	.50	81
6	81.5	3.1	79.3	5.3	.979	.48	1.91	.85
7	80.9	3.6	78.4	6.1	.952	.19	2.16	.83
8	81.3	4.5	78.1	7.7	.943	.06	.77	.78
9	81.8	3.7	79.2	6.3	.976	.43	.29	.82
10	82.0	4.6	79.2	7.4	.976	.41	.73	.79
11	82.0	3.4	79.6	5.8	.989	.56	.12	.83
12	81.8	4.5	78.6	7.7	.958	.21	.81	.78
13	82.0	4.1	79.1	7.0	.973	.38	.57	.80
14	81.7	4.2	78.8	7.1	.964	.29	.58	.80
15	81.3	4.1	78.4	7.0	.952	.17	.51	.80
16	80.7	2.7	78.8	4.6	.964	.34	1.62	.87
17	80.8	3.0	78.7	5.1	.961	.31	.79	.85
18	81.3	3.2	79.1	5.4	.973	.42	.93	.84
19	81.9	2.9	79.9	4.9	.998	.67	.79	.86
20	81.7	3.4	79.3	5.8	.979	.46	2.11	.83
21	80.7	2.6	78.9	4.4	.967	.39	1.54	.87
22	80.7	1.9	79.4	3.2	.983	.56	.12	.90
23	81.4	3.0	79.3	5.1	.979	.48	.83	.85
24	82.0	3.1	79.8	5.3	.995	.64	.93	.85
25	81.7	2.3	80.1	3.9	1.005	.75	.42	.88
26	81.8	3.6	79.3	6.1	0.979	.46	2.22	.83
27	81.5	3.2	79.3	5.4	.979	.48	1.94	.84
28	79.5	1.7	78.3	2.9	.949	.22	0.99	.91
29	80.5	2.0	79.1	3.4	.973	.47	1.17	.90
30	81.7	3.4	79.3	5.8	.979	.46	2.11	.83
31	81.5	4.1	78.6	7.0	.958	.26	.53	.80

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of August, 1865.

Hourly Means, &c. of the Observations and of the Hygrometrical elements dependent thereon.

Hour.	Mean Height of the Barometer at 32° Faht.	Range of the Barometer for each hour during the month.			Mean Dry Bulb Thermometer.	Range of the Temperature for each hour during the month.		
		Max.	Min.	Diff.		Max.	Min.	Diff.
	Inches.	Inches.	Inches.	Inches.	o	o	o	o
Mid-night.	29.616	29.764	29.396	0.368	82.6	84.8	79.8	5.0
1	.633	.758	.379	.379	82.4	84.6	80.2	4.4
2	.620	.744	.311	.433	82.1	84.4	80.2	4.2
3	.611	.734	.316	.418	81.8	84.1	80.2	3.9
4	.607	.734	.325	.409	81.6	84.2	79.4	4.8
5	.615	.746	.334	.412	81.3	82.8	78.3	4.5
6	.630	.756	.347	.409	81 3	82.8	77.6	5.2
7	.646	.765	.359	.406	82.1	83.8	77.2	6.6
8	.660	.767	.405	.362	83.6	85.8	77.6	8.2
9	.668	.777	.431	.346	85.1	87.6	78.0	9.6
10	.668	.776	.443	.333	86.4	89.2	78.6	10.6
11	.661	.779	.439	.340	67.6	90.6	79.4	11.2
Noon.	.642	.755	.417	.338	88.4	91.4	80.6	10.8
1	.620	.734	.402	.332	88.5	91.6	81.2	10.4
2	.595	.710	.360	.350	88.3	92.2	81.4	10.8
3	.576	.698	.344	.354	87.7	92.6	82.6	10.0
4	.563	.686	.333	.353	87.1	91.4	82.8	8.6
5	.563	.691	.330	.361	86.3	90.4	82.8	7.6
6	.571	.697	.331	.366	85.3	88.2	83.0	5.2
7	.590	.716	.353	.363	84.5	86.8	81.6	5.2
8	.617	.736	.379	.357	84.1	86.4	81 9	4.5
9	.610	.755	.409	.346	83.8	85.6	81.1	4.5
10	.654	.766	.424	.342	83.4	85.0	80.7	4.3
11	.653	771	.416	.355	83.0	84.8	81.0	3.8

The Mean Height of the Barometer, as likewise the Dry and Wet Bulb Thermometer Means are derived from the Observations made at the several hours during the month.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of August, 1865.

Hourly Means, &c. of the Observations and of the Hygrometrical elements dependent thereon.—*(Continued.)*

Hour.	Mean Wet Bulb Thermometer.	Dry Bulb above Wet.	Computed Dew Point.	Dry Bulb above Dew Point.	Mean Elastic force of Vapour.	Mean Weight of Vapour in a Cubic foot of air.	Additional Weight of Vapour required for complete saturation.	Mean degree of Humidity, complete saturation being unity.
	o	o	o	o	Inches.	Troy grs.	Troy grs.	
Midnight.	80.8	1.8	79.5	3.1	0.986	10.60	1.08	0.91
1	80.8	1.6	79.7	2.7	.992	.66	0.95	.92
2	80.6	1.5	79.5	2.6	.986	.60	.91	.92
3	80.4	1.4	79.4	2.4	.983	.58	.82	.93
4	80.3	1.3	79.4	2.2	.983	.58	.76	.93
5	80.0	1.3	79.1	2.2	.973	.49	.75	.93
6	80.0	1.3	79.1	2.2	.973	.49	.75	.93
7	80.5	1.6	79.4	2.7	.983	.56	.95	.92
8	81.1	2.5	79.3	4.3	.979	.51	1.52	.87
9	81.6	3.5	79.1	6.0	.973	.40	2.17	.83
10	81.8	4.6	78.6	7.8	.958	.21	.85	.78
11	82.3	5.3	79.1	8.5	.973	.34	3.18	.77
Noon.	82.4	6.0	78.8	9.6	.964	.23	.61	.74
1	82.5	6.0	78.9	9.6	.967	.26	.62	.74
2	82.4	5.9	78.9	9.4	.967	.28	.52	.75
3	82.2	5.5	78.9	8.8	967	.28	.28	.76
4	82.0	5.1	78.9	8.2	.967	.30	.03	.77
5	81.7	4.6	78.5	7.8	.955	.18	2.84	.78
6	81.4	3.9	78.7	6.6	.961	.26	.38	.81
7	81.2	3.3	78.9	5.6	.967	.34	.01	.84
8	81.2	2.9	79.2	4.9	.976	.45	1.76	.86
9	81.1	2.7	79.2	4.6	.976	.45	.65	.86
10	81.0	2.4	79.3	4.1	.979	.51	.45	.88
11	81.0	2.0	79.6	3.4	.989	.63	.19	.90

All the Hygrometrical elements are computed by the Greenwich Constants.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of August, 1865.

Solar Radiation, Weather, &c.

Date.	Max. Solar radiation.	Rain Gauge 5 feet above Ground.	Prevailing direction of the Wind.	General Aspect of the Sky.
	°	Inches		
1	131.7	1.72*	S. & S. E.	Overcast to 2 P. M. ⌒i & \i afterwards. Rain from Midnight to 9 A. M.
2	...	0.75	S. & S. E.	Overcast. Rain at midnight & 3 A. M. & from 5 to 11 A. M.
3	126.0	...	S.	\i & ⌒i to 2 P. M. Overcast afterwards.
4	126.0	...	S.	\i & ⌒i.
5	131.0	...	S.	╰i to 3 A. M. Scud. from S. to 7 A. M. ⌒i afterwards.
6	122.4	...	S.	⌒i to 7 P. M. \i afterwards. Thin rain at 2 & 4 P. M.
7	124.0	...	S.	Overcast to 6 A. M. ⌒i to 5 P. M. Cloudless afterwards. Thin rain at 1 & 3 A. M. & 5 P. M.
8	128.4	...	S. & S. W.	Cloudless to 4 A. M. ╰i to 3 P. M. \i & ⌒i afterwards.
9	125.0	0.22	S.	╰i & ⌒i to 2 P. M. Overcast afterwards. Rain at 2 A. M. & 3 P. M.
10	129.0	...	S.	╰i to 6 A. M. ⌒i afterwards.
11	131.4	...	S.	∿i to 7 A. M. ⌒i to 3 P. M. Cloudless afterwards. Light rain at 2 & 3 P. M.
12	131 6	...	S.	╰i to 6 A. M. ⌒i to 2 P. M. ∿i afterwards.
13	127.0	...	S.	Cloudless to 5 A. M. ⌒i to 9 P. M. Cloudless afterwards. Light rain at 8 P. M.
14	134.0	...	S.	Cloudless to 5 A. M. ⌒i to 6 P. M. ╰i to the E. afterwards. Thin rain at 1 P. M.
15	137.0	...	S. E. & E. & S.	╰i & \i to 10 A. M. ⌒i afterwards. Light rain between 2 & 3 P. M.
16	126.0	0.20	S. E. & E. & S.	Cloudless to 2 A. M. Overcast to 7 P. M. Cloudless afterwards. Rain at 2, 3, 5 & 6 P. M.
17	129.6	0.13	S.	Overcast to 7 A. M. ∿i to 1 P. M. Overcast to 6 P. M. Cloudless afterwards. Rain at 1, 5 & 6 A. M.
18	131.5	...	S. & E.	Cloudless to 4 A. M. ⌒i to 7 P. M. Cloudless afterwards. Light rain at 3 P. M.
19	132.0	0.18	S. & S. E.	Cloudless to 5 A. M. ⌒i to 8 P. M. Cloudless afterwards. Thin rain at 2, 5 & 6 P. M.
20	129.0	0.12	E. & S. E.	⌒i. Thin rain at 1, 2 & 6 P. M.

\i Cirri, —i Strati, ⌒i Cumuli, ╰i Cirro-strati, ⌒—i Cumulo-strati, ∿i Nimbi, \⌒i Cirro cumuli.

* Fell from 2 P. M. of the 31st July to 9 A. M. of the 1st.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of August, 1865.

Solar Radiation, Weather, &c.

Date.	Max. Solar radiation.	Rain Gauge 5 feet above Ground.	Prevailing direction of the Wind.	General Aspect of the Sky.
	o	Inches		
21	...	0.51	N. E. & E.	Overcast to 1 P. M. \-i to 9 P. M. Overcast afterwards. Rain at 10 A. M. noon, 1, 3 & 11 P. M.
22	...	0.44	S. E. & E.	Overcast to 4 P. M. \-i to 8 P. M. Cloudless afterwards. Drizzled after intervals.
23	120.0	0.13	S.	Cloudless to 3 A. M. ⌒i to 9 P. M. Thin rain at 4 & 8 A. M. noon & 5 P. M.
24	129.8	...	S. & S. E.	Overcast to 7 A. M. ⌒i to 3 P. M. \-i afterwards. Light rain at 2 A. M.
25	126.5	0.22	Variable.	Overcast to 7 P. M. \-i & Lightning afterwards. Thunder at 9 A. M.
26	137.4	...	N. E. & S.	Clouds of various kinds. Lightning at midnight & 1 A. M.
27	122.4	...	N. & N. E.	Overcast to 2 P. M. \-i afterwards. Light rain at 3, 5 & 11 P. M.
28	...	0.79	S. E. & E. & S.	Overcast. Rain from midnight to 2 P. M. & at 7 P. M.
29	...	0.58	S. E. & S.	Clouds of various kinds. Rain at 3, 6, 10 & 11 A. M.
30	129.0	...	S. & W.	Cloudless to 5 A. M. ⌒i afterwards.
31	129.0	...	S. & W.	\-i to 7 A. M. \i to 10 A. M. Overcast to 4 P. M. Cloudless afterwards.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of August, 1865.

MONTHLY RESULTS.

	Inches
Mean height of the Barometer for the month, ...	29.623
Max. height of the Barometer occurred at 11 A. M. on the 17th, ..	29.779
Min. height of the Barometer occurred at 2 A. M. on the 28th, ..	29.311
Extreme range of the Barometer during the month, ...	0.468
Mean of the Daily Max. Pressures, ...	29.685
Ditto ditto Min. ditto, ...	29.553
Mean daily range of the Barometer during the month, ...	0.132

	o
Mean Dry Bulb Thermometer for the month, ...	84.5
Max. Temperature occurred at 3 P. M. on the 5th & 26th, ...	92.6
Min. Temperature occurred at 7 A. M. on the 2nd, ...	77.2
Extreme range of the Temperature during the month, ...	15.4
Mean of the daily Max. Temperature, ...	89.7
Ditto ditto Min. ditto, ...	81.1
Mean daily range of the Temperature during the month, ...	8.6

Mean Wet Bulb Thermometer for the month, ...	81.3
Mean Dry Bulb Thermometer above Mean Wet Bulb Thermometer, ..	3.2
Computed Mean Dew-point for the month, ...	79.1
Mean Dry Bulb Thermometer above computed Mean Dew-point, ..	5.4
	Inches
Mean Elastic force of Vapour for the month, ...	0.973

	Troy grains
Mean Weight of Vapour for the month, ...	10.42
Additional Weight of Vapour required for complete saturation, ..	1.93
Mean degree of humidity for the month, complete saturation being unity,	0.84

	Inches
Rained 22 days, Max. fall of rain during 24 hours, ...	1.72
Total amount of rain during the month, ...	5.99
Prevailing direction of the Wind, ...	S. & S. E.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of August, 1865.

Monthly Results.

Tables showing the number of days on which at a given hour any particular wind blew, together with the number of days on which at the same hour, when any particular wind was blowing, it rained.

Hour.	N.	Rain on.	N. E.	Rain on.	E.	Rain on.	S. E.	Rain on.	S.	Rain on.	S. W.	Rain on.	W.	Rain on.	N. W.	Rain on.	Calm.	Rain on.	Missed.
									No. of days.										
Midnight.	1		1		4	1	1		22	1	1	1					1		
1	1		2		3	2	4		20	3							1		
2	1		1		4	1	4		19	2							2		
3	1		3		4		5	2	18	2									
4	1		2		4	2	6		18	2									
5	1		2		5		5	2	18										
6	2		1		5	2	5	3	17	2	1								
7	2				7	2	4		17		1	1							
8	3	1			5		6	3	14		2	1	1						
9	1		3		3		7	2	13	1	3	1	1						
10	1		3	1	1		9	3	13		2		2						
11	1		1		3	1	8	2	15	1	1		2						
Noon.	1		3	1	2		7	1	13	1	2		3						
1	2		3	2	2		4	2	15	1	2		3						
2	3		1		5	2	4	2	15	2	1		2						
3	2	1	1	1	3	1	8	4	15	2	1		1						
4	2				2		10		13	1	4								
5	1	1	1	1	2		8	1	15	2	4								
6	1		2		1	1	6	1	19	1	2								
7	1		2		2		3	2	23										
8			2		2		2		21	1							1		
9			2		2		1		25								1		
10					3		2		25								1		
11					3	1	2	1	25								1		

Meteorological Observations taken at Gangaroowa near Kandy, Ceylon, in the month of May, 1864.

Alt. 1560 ft.; E. Long. 80° 37′, N. Lat. 7° 17′.

All the Instruments have been compared with standards.

The tension of aqueous vapour, dew point and humidity, have been found from the readings of the dry and wet bulb Thermometers by Mr. Glaisher's Hygrometrical tables (Ed. 1863).

The dew is the weight in grains deposited on a square foot of ordinary woollen cloth exposed on a board from 6 P. M. to 6 A. M. or for as many hours as there is no rain.

The evaporation is given by a Babington's Atmidometer placed under cover, so as to be protected from the sun, rain and dew, but freely exposed to the wind.

The ozone cage is hung about 25 feet above the ground.

The direction of the wind given, is that of the lowest current, by the vane; and of the currents above this, by the direction in which the Nimbi and Cumulo-Strati clouds are moving.

In this column a "calm" signifies that the clouds are apparently motionless: "variable," that the clouds, apparently in the same or nearly the same stratum, move in no fixed direction, but their parts move as if in vortices, or different masses of them move up from different quarters as if into a vast vortex, this being nearly always the case before thunder storms.

Entries, such as $\frac{\text{W S W}}{\text{N N W}}$, or $\frac{\text{W S W}}{\text{N N W}}\frac{}{\text{calm}}$, signify that the clouds are evidently in strata of different altitudes, that those in the lowest stratum move from W S W; those in the next higher from N N W; those in the next are apparently becalmed, and so on.

The velocity and distance in 24 hours are given by Robinson's Anemometer.

In the column for Lightning and Thunder—

L = "Lightning," when the flash is near enough to be visible.

L R = "Lightning Reflection," when the flash is so distant that only its reflection on the clouds or in the air is visible.

"Morn," is 6 A. M., "Even," 6 P. M., and "Night," 12 P. M., and "fore" and "after" are prefixed to these, as ordinarily to "Noon," to denote the 3 previous and 3 following hours.

R. H. Barnes.

Gangaroowa near Kandy, Ceylon.

May, 1864.	Barometer reduced to 32°.			Pressure of Dry Air.			Thermometer.			Dew Point.		
	A. M. 9.30	P. M. 3.30	P. M. 10.0	A. M. 9.30	P. M. 3.30	P. M. 10.0	A. M. 9.30	P. M. 3.30	P. M. 10.0	A. M. 9.30	P. M. 3.30	P. M. 10.0
1	28.398	28.276	28.362	27.694	27.577	27.665	77.6	81.6	71.9	68.8	68.6	68.5
2	.391	.267	.358	.635	.539	.602	73.3	78.4	72.3	70.9	69.8	70.9
3	.365	.285	.896	.624	.524	675	75.5	73.0	71.1	70.3	71.1	69.5
4	.397	.301	.368	.643	.555	.627	76.6	72.8	71.2	70.8	70.5	70.3
5	.392	.283	.363	.615	.547	.664	74 1	75.4	70.0	71.7	70.1	68.6
6	.338	.242	.330	.564	.491	.622	75.8	78.2	70.6	71.6	70.7	69.0
7	.330	.216	.307	.689	.467	.589	76.1	77.9	71.4	66.1	70.6	69.4
8	.330	.236	.336	.622	.477	.620	75.4	77.8	71.8	69.0	71.0	69.3
9	.358	.258	.348	.630	.504	.630	75.4	78.3	72.2	69.7	70.8	69.4
10	.355	.254	.344	.668	.493	.583	77.3	80.5	73.3	68.1	71.1	71.1
11	.349			.674			77.1			67.6		
12	.375	.260	.376	.678	.445	.625	74.2	78.8	71.8	68.5	73.1	70.7
13	.388	.298	.370	.637	.505	.626	75.5	77.7	72.2	70.7	72.3	70.4
14	.401	.260	.370	.629	.450	.596	76.1	79.3	73.0	71.5	72.9	71.6
15	.361	.241	.349	.615	.431	.628	76.6	80.1	73.7	70.5	72.9	69.5
16	.347	.212		.663	.471		76.8	81.8		68.0	70.3	
17	.345	.252	.344	.667	.588	.572	76 9	71.5	73.2	67.7	67.1	71.5
18	.389	.290	.377	.628	.574	.680	76.9	72.3	70.1	71.1	69.3	68.5
19	.376	.257	.346	.655	.469	.572	74.7	80.8	73.1	69.5	72.1	71 6
20	.371	.241	.368	.617	.426	.655	76.4	79.9	71.0	70.8	73.1	69.2
21	.330	.219	.304	.594	.423	.535	75.4	79.1	72.8	70.1	72.4	71.4
22	.356	.259	.358	.600	.560	.630	76.5	78 1	72.6	70.9	68.6	69.8
23	.374		.333	.638		.532	76.4		74.5	70.1		72.6
24	.335	.227	.307	.619	.439	.541	77.3	80.8	74.2	69.3	72.1	71.3
25	.314	.178	.272	.560	.417	.465	78 3	82.0	76.0	70.8	71.1	72.8
26	.270	.183	.290	.493	.395	.531	78.3	80.8	73.5	71.7	72.1	71.0
27	.274	.190	.277	.558	.454	.544	76.8	79.4	72.3	69.3	70.1	70.0
28	.286	.204	.301	.618	.448	.568	77.2	79.6	73.5	67.3	70.9	70.0
29	.315	.231	.354	.631	.467	.646	76.3	79 4	73.7	68.6	71.2	69.0
30	.333	.229		.615	.498		77.4	79.7		69.4	69.9	
31	.303	.230	.316	.577	.453	.590	76.0	75.4	72.2	69.7	71.7	69.7
	28.350	28.244	28.340	27.624	27.486	27.600	76.3	78.3	72.5	69.7	70.9	70.2

Gangaroowa near Kandy, Ceylon.

Humidity.			Max. in Sun.	Minimum on Grass.	Maximum in Air.	Minimum in Air.	Difference.	Mean.	A. M. 9.30						
A. M. 9.30	P. M. 3.30	P. M. 10.0							Cirrus.	Cirro-Stratus.	Cirro-Cumulus.	Cumulus.	Cumulo-Stratus.	Nimbus & Stratus.	Total.
742	649	895	143.8	63.0	81.7	66.3	15.4	74.0	0	0	0	0.2	7.3	0	7.5
920	746	953	137.0	66.3	79.3	70.0	9.3	74.7	0	0	0	0	0	10.0	10.0
840	935	947	131.0	68.8	77.9	70.8	7.1	74.3	2.0	0	0	0	0	8.0	10.0
820	926	971	130.7	67.1	77.0	68.7	8.3	72.9	0.2	0	2.0	0	0	7.4	9.6
920	835	952	117.2	70.6	76 1	70.0	6.1	73.0	0	0	0	0	0	10.0	10.0
865	774	946	141.0	62.1	79.7	65.2	14.5	72.5	0	0	0.4	0	5.0	0	5.4
730	775	937	138.8	62.5	79.7	65.1	14.6	72.4	5.6	0	0	0.1	1.3	0	7.0
830	792	921	141.8	63.2	79.7	66.8	12.9	73.2	4.0	0	3.5	0	1.5	0	9.0
850	774	910	135.9	66.7	79.3	68.4	10.9	73.9	0	0	3.0	0	0	7.0	10.0
734	726	925	142.7	65.6	80.5	69.1	11.4	74.8	0	7.0	0	0	1.7	0	8.7
726				63.0	79.8	67.7	12.1	73.7	0	6.8	0.4	0	1.2	0	8.4
825	820	964	146.8		79.5	65.3	14.2	72.4	0	0	0	0	2.0	0	2.0
850	830	953	155.0	67.2	80.8	70.8	10.0	75.8	0.5	0	0.3	0	1.2	0	2.0
855	811	952	139.8	68.2	80.1	70.3	9.8	75.2	0	0	1.0	0	8.0	0	9.0
810	786	870	140.9		80.8	68.9	11.9	74.9	2.0	0	0	0	3.5	0	5.5
740	684		145.2	63.8	81.4	68.0	13.4	74.7	1.9	0	0.3	0	1.6	0	3.8
764	855	942	143.0		81.0	68.9	12.1	74.9	8.6	0	0	0	0.4	0	9.0
820	905	946	138.0	69.2	79.3	71.6	7.7	75.5	1.5	0	0.5	0	6.0	0	8 0
840	748	947	147.2	64.0	80.8	66.6	14.2	73.7	9.0	0	0	0	0.5	0	9.5
825	801	940	145.1	67.6	80.2	71.0	9.2	75.6	1.5	0	0	0	6.5	0	8.0
835	801	952	147.6	63.9	80.2	67.5	12.7	73.8	8.8	0	0	0	0.2	0	9.0
825	726	910	149.5	69.2	81.2	70.6	10.6	75.9	0	0	0	0	3.3	0	3.3
806		937	140.5	68.1					0	0	0	0	2.0	0	2.0
762	748	905	139.8	65.3	81.3	68.8	12.5	75.1	1.5	0	0	0	2.5	0	4.0
774	700	895	140.3	67.3	82.4	71.2	11.2	76.8	1.6	0	0	0.2	3.4	0	5.2
797	748	915	140.2	69.2	81.9	71.8	10.1	76 8	6.0	0	0	0	4.0	0	10.0
775	730	925	138.0	67.9	80.4	71.3	9.1	75.9	0	9.6	0.3	0	0.1	0	10.0
718	746	890	144.0	66.0	80.8	69.5	11.3	75.1	7.3	0	2.0	0	0.7	0	10.0
770	759	855	138.4	66.5	81.3	71.0	10.3	76.2	1.5	0	6.0	0	1.5	0	9.0
762	718		128.9	66.4	81.3	71.1	10.2	76.2	0.8	0	0	0	9.0	0	9.8
805	880	920	131.0	68.3	78.8	70.9	7.9	74.9	4.7	0	0.3	0	0.2	4.8	10.0
804	784	928	140.0	66.3	80.1	69.1	11.0	74.6	2.2	0.8	0.6	0.1	2.4	1.5	7.6

Gangaroowa near Kandy, Ceylon.

May, 1864.	P. M. 3.30							P. M. 10.0						
	Cirrus.	Cirro-Stratus.	Cirro-Cumulus.	Cumulus.	Cumulo-Stratus.	*Nimbus* & Stratus.	Total.	Cirrus.	Cirro-Stratus.	Cirro-Cumulus.	Cumulus.	Cumulo-Stratus.	*Nimbus* & Stratus.	Total.
1	0	7.2	0	0	2.5	0	9.7	0	0	0	0	1.5	0	1.5
2	0	4.4	1.0	0	0.4	4.0	9.8	6.5	0	0	0	2.5	0	9.0
3	0	0	6.0	0	0	4.0	10.0	0	0	0	0	0	3.0	3 0
4	0	0	0	0	0	10.0	10.0	0	0	0	0	0	10.0	10.0
5	4.0	0	1.5	0	4.5	0	10.0	0	0	0	0	0	0	0.0
6	0.1	0	0	0	0	9.2	9.3	0	0	0	0	0.2	0	0.2
7	6.0	0	0	0	2.0	0	8.0	0.3	0	0	0	0.6	0	0.9
8	0	8.2	0.1	0	0	1.7	10.0	0	0	0	0	7.0	0	7.0
9	0.5	0.5	0.2	0	0	6.3	7.5	0	0	0	0	3.3	0	3.3
10	0.4	1.0	2.0	0	3.3	0	6.7	0	0	0	0	0.7	0	0.7
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0.1	0.1	0	0	7.8	8.0	0	0	0	0	0	10.0	10.0
13	0	0	0	0	0	9.8	9.8	0	0	0	0	6.0	0	6.0
14	0	1.4	0	0	0	8.4	9.8	0	0	0	0	0	10.0	10.0
15	0	3.0	0	0	5.0	0	8.0	0	0	0	0	9.0	0	9.0
16	0	4.0	0	0	4.0	0	8.0	0	0	0	0	0	0	0
17	0.1	0	0	0	0	9.7	9.8	0	0	0	0	0	10.0	10.0
18	0	8.5	0	0	0	1.5	10.0	3.3	0	0.1	0	0	0	3.4
19	0.1	0.1	0	0	0	5.8	6.0	0	1.2	0	0	4.0	0	5.2
20	2.1	0.4	0	0	2.5	5.0	10.0	1.6	0	7.8	0	0	0	9.4
21	0.6	6.2	0.2	0	0	3.0	10.0	0	2.4	0	0	7.0	0	9.4
22	0	1.2	0	0	4.8	0	6.0	0	0	0	0	9.0	0	9.0
23	0	0	0	0	0	0	0	7.5	0	2.5	0	0	0	10.0
24	0	0	0	0	6.7	0	6.7	0	0	5.0	0	4.0	0	9.0
25	8.0	0	0	0	2.0	0	10.0	6.0	0	1.0	0	3.0	0	10.0
26	4.6	0	0.4	0	5.0	0	10.0	5.0	0	0	0	5.0	0	10 0
27	0.2	0	9.0	0	0.6	0	9.8	0	0	10.0	0	0	0	10.0
28	0.3	0	7.7	0	2.0	0	10.0	0	0	0	0	2.5	0	2.5
29	2.5	0	4.0	0	3.5	0	10.0	0.7	0	0	0	9.3	0	10.0
30	7.5	0	0.5	0	2.0	0	10.0	0	0	0	0	0	0	0
31	0	0.3	0.7	0	0	9.0	10.0	0	0	0	0	0	10.0	10.0
	1.3	1.6	1.2	0.0	1.7	3.3	9.1	1.1	0.1	0.9	0.0	2.7	1.9	6.7

Gangaroowa near Kandy, Ceylon.

Dew in Grs. per sqr. ft.	Evaporation in Grs. per sqr. ft.	Rain. At 4½ feet. A. M. 9.30	P. M. 10.0	Total.	Rain. At 30 feet. A. M. 9.30	P. M. 10.0	Total.	Ozone. 6 A. M.	6 P. M.	9.30 A.M. Direction of wind. Vane.	Lower Clouds.	Velocity in feet per Second.
285	5000	0.000	0.000	0.000	0.000	0.000	0.000	2	1	W S W	S S W	6.95
65	2710	0.280	0.021	0.301	0.276	0.000	0.276	2	2	S S E	S W	1.76
135	2020	0.001	0.185	0.186	0.000	0.165	0.165	1	3	W by S	W S W	9.94
60	2020	0.000	0.655	0.655	0.000	0.635	0.635	0	3	W S W	W by S	14.61
0	1900	0.422	0.175	0.597	0.420	6.163	0.583	2	2	W S W	W by S	13.38
355	5210	0.000	0.000	0.000	0.000	0.000	0.000	0	1	W	W S W	6.69
470	5360	0.000	0.088	0.088	0.000	0.085	0.085	0	1.5	W S W	W S W	10.82
440	3940	0.000	0.000	0.000	0.000	0.000	0.000	0.5	1.5	W N W	S W	3.52
45	3590	0.019	0.000	0.019	0.017	0.000	0.017	1	1	W by N	S W	0.44
220	4880	0.000	0.000	0.000	0.000	0.000	0.000	0.5	1	W S W	Variable	9.68
345	} 5510	0.000	1.664	1.664	0.000	1.485	1.485	0	2	Variable	Calm	1.23
300		0.000	0.895	0.895	0.000	0.869	0.869	1	2	W by N	Variable	0.70
	2680	0.098	0.094	0.192	0.096	0.090	0.186	0	1	Variable	Variable	0.10
165	2930	0.000	0.013	0.013	0.000	0.018	0.018	0	1	W S W	W by S / Calm	3.78
	4600	0.009	0.000	0.009	0.005	0.000	0.005	0	1	W S W	Variable	9.77
275	} 7580	0.000	0.000	0.000	0.000	0.000	0.000	0	1	W S W	S S W	3.08
265		0.000	0.422	0.422	0.000	0.430	0.430	0	1	N	Calm	0.97
210	2320	0.000	0.075	0.075	0.000	0.072	0.072	0	1	W S W by	Variable	0.00
455	3030	0.000	0.115	0.115	0.000	0.108	0.108	0	0.5	N N W by	Calm	0.00
295	3590	0.000	2.133	2.133	0.000	2.112	2.112	0	1	W by N	Variable	1.50
240	2930	0.000	0.545	0.545	0.000	0.523	0.523	0	0.5	W by	Calm	0.00
235	3590	0.000	0.000	0.000	0.000	0.000	0.000	0	0	Variable	Variable	0.88
50	4750	0.020	0.000	0.020	0.017	0.000	0.017	0.5	0.5	S W	S W by S	4.22
115	5410	0.000	0.000	0.000	0.000	0.000	0.000	0.5	1	W by S	S S W	9.24
165	5100	0.000	0.000	0.000	0.000	0.000	0.000	1	1	W by S	W S W / E N E	8.54
170	4600	0.000	0.000	0.000	0.000	0.000	0.000	2	1	W S W by	S W / Calm	4.66
230	4050	0.000	0.000	0.000	0.000	0.000	0.000	2	2	S by E	Calm	2.55
105	4900	0.000	0.002	0.002	0.000	0.002	0.002	2	2	S W	W S W	6.69
330	4700	0.000	0.000	0.000	0.000	0.000	0.000	3	1	S W by W	W S W	8.71
115	5260	0.000	0.000	0.000	0.000	0.000	0.000	2	1	W S W	S W	11.62
65	3280	0.114	0.216	0.330	0.112	0.187	0.299	4	3	S S W	S W / Calm	5.63
6205	3788	0.963	7.298	8.261	0.943	6.944	7.887	0.9	1.3	......	......	5.21

May, 1864.	3.30 P. M. Direction of wind. Vane.	Lower Clouds.	Velocity in ft. per Second.	10.0 P. M. Direction of wind. Vane.	Lower Clouds.	Velocity in ft. per Second.
1	W	S W	9.42	N W	Too dark	4.31
2	S S W	S W	6.78	N W	?	4.31
3	Calm	W	0.00	W N W	W	1.76
4	W S W	Calm	2.82	N	Too dark	3.52
5	W S W	W by S	5.90	N W	None	3.96
6	N W	W by S / Calm	3.61	N W by W	?	0.88
7	W by S	W S W / Calm.	11.88	W N W	?	1.76
8	W N W	S W	9.06	W N W	Too dark	6.16
9	W	S W / Calm	15.49	N by W	Variable	0.53
10	W by S	S W	6.42	S W by W	?	4.22
11	......	......	0	......	......	0
12	W	S E / Variable	4.93	W N W	Too dark	0.62
13	Calm	Calm	0.00	W N W	Calm	2.02
14	N W by N	W / Calm	5.46	S E by E	Calm	0.70
15	W by S	Variable	6.86	W S W	Variable	6.16
16	W	W by N / Calm	11.79	......	......	0
17	E by	Calm	0.44	N W	E N E	0.18
18	W N W	E by N	3.34	Calm	None	0.00
19	N W	Variable	6.95	Calm	Variable	0.00
20	W by S	Var. / W by N, Calm	11.09	W by N	None	0.88
21	W	E N E / Calm	3.96	W N W	E	0.53
22	S by	S S E	8.89	Calm	S W	0.00
23	......	......	0	W S W	None	0.00
24	W S W	W S W / E N E	13.20	W	W S W	2 38
25	W by S	W / E	9.94	S S W	W	2.29
26	W by S	W S W / Calm	14.17	N W	S S W	2.90
27	W N W	S / Calm	9.50	N W	None	6.16
28	W by N	W S W / Calm	8.18	N W	Too dark	3.78
29	W by	W S W	6 86	W	Too dark	2.99
30	W	W S W / Calm	9.50	......	......	0
31	S W	S W by W	7.04	W	S W by W	1.94

Gangaroowa near Kandy, Ceylon.

Distance in Miles in 24 Hours.	Lightning and Thunder.
94.88	In forenoon Th.
63.88	
48.57	In afternoon L & Th. near. In after even L R to S S W, S S E & S b W.
58.10	In fore & afternoon Th. In fore even & early after even L & Th. dist. a few miles, later in after even L or L R dist.
55.37	In fore even Th. & in after even L R to S S E.
90.98	In after even bright L R to N E—N N E.
99.90	In later part of after even L R to W & N E.
85.10	At even & early after even L to N E & later L R to N E.
83.95	In afternoon Th. & in after even L R to N E.
89.18	In afternoon & fore even L & Th. dist. a few miles & L in early after even.
84.11	In afternoon Th. in fore even L & Th. near, & in after even L R & Th. very dist. to N & N E. [to S, N N W, N E, N N E.
	In afternoon Th., in fore even dist. Th. & L Th. near, in after even L R
28.41	In forenight Th. & again in forenoon, in fore even L & Th. dist. a few miles, in after even L R to N E & S. [& N E.
54.55	In fore even L & Th. dist. a few miles, & in after even L & L R to E N E
81.61	In afternoon Th. & in fore even L & Th. dist. a few miles.
99.83	In afternoon L & Th. dist. & very near, in after even L & Th. in all W quarter dist. 12 or 14 miles & L R to N, N W, & N E. [W N W.
26.50	L & Th. dist. some miles in afternoon to S—S W & in fore even to W—
29.21	L & Th. in fore even dist. some miles in all W half & at 10 P. M. dist. 12—15 miles to W N W—N W & L R to S S E—S.
46.42	In fore even L & Th. dist. from one to several miles.
41.69	In afternoon & fore even Th., L R to E S E in early after even & later L & Th. dist. 12 to 15 miles to N N E.
54.99	Th. in afternoon and early fore even.
75.62	At even L to E N E & N E & later L R to S E. [to W—W S W.
95.24	In early after even bright L R to S S W & later L R & Th. Very dist.
101.90	In early after even L R to S S W.
101.64	In after even L R to S—S S W.
75.13	In after even L R to E—E N E.
95.52	In early fore even Th. & early after even L R to Eward.
115.58	In early after even L R to N E & later to N W.
128.40	
126.52	
72.03	

GANGAROOWA NEAR KANDY, CEYLON.

May, 1864.	GENERAL REMARKS.
1	Fine, warm to hot & pleasant day, heavy threaten. clouds in fore even but
	no rain. [in fore even.
2	Mild to warm & damp day, light rain fore & afternoon, the Nim. break up
3	Mild to warm, damp & cloudy with showers all day. [heavier.
4	As on previous day, but in afternoon & fore even rain more continuous &
5	As on previous day, till later part of afternoon when fine & pleasant, sky in
	after even cloudless. [& fore even, in after even sky cloudless.
5	Cool fresh, morn; warm to hot, damp but fine day, heavy clouds in afternoon
6	As on previous day, but drier in afternoon & forenoon, and a short shower
	between 4 & 5 P. M. [even, but no rain.
7	Fine, mild to warm & pleasant day, heavy clouds in fore even & early after
8	Some rain in forenoon, mild to warm, damp & pleasant, Nim. more or less
	all day but no rain. [clouds in afternoon & fore even.
9	Mild damp morn, fine warm to hot, sultry in afternoon, heavy threaten.
10	Fine, fresh afternoon, heavy clouds gathered in forenoon, storm in afternoon,
	& light rain fore & after even. [in the fore even.
11	Warm to hot & oppressive before the rain, then mild & damp, heavy rain
12	Warm to hot, damp & oppressive day, heavy clouds gathered in afternoon,
13	As on previous day, only a little rain in fore & after even. [rain all fore even.
14	A little rain during night, damp & oppressive day, pleasant after even,
	heavy clouds in afternoon & fore even. [but no rain.
15	Fresh morn, fine hot & pleasant day, heavy threatening clouds in fore even.
16	Fresh morn, oppressive fore & afternoon, raw & damp after 3.30 P. M. in
	afternoon & Nim. covered the sky. Rain in fore even.
17	Mild to warm & oppressive & damp day, in afternoon Nim. covered the sky,
	light rain in afternoon & fore even. [rain in fore even.
18	Fog at morn, warm to hot & oppressive day Nim. gathered in afternoon &
19	Very damp morn. Warm to hot & oppressive till the rain Nim. gathered in
20	As on the previous day. [afternoon. Very heavy rain from 4.40 to 6 P. M.
21	Mild to hot & pleasant except at noon when oppressive, heavy rain to S.
	but none here. [in afternoon & fore even, but broke up without rain.
22	Rain in after night. Mild to hot & pleasant till even, then sultry heavy Nim.
23	Fine mild to hot fresh day, sultry after even, scatd. clouds.
24	Fine mild to hot day, pleasant till forenoon & after very sultry. Cirri cover.
	sky nearly all day. [in fore even, heavy threatening Nimbi.
25	Mild to hot day, pleasant till forenoon & then oppressive & sultry. Cloudy,
26	Fine mild to hot & pleasant day, cloudy Cirro-Strati & Cirro-Cumuli.
27	Mild to hot pleasant day, cloudy till after 8 P. M. with Cirri & Cir. Cum. &
	from 4 to 7 P. M. when a little rain, with Nimbi. [sky all day.
28	Mild to hot day, oppressive & afternoon. Clouds, low & high, covering the
29	As on the previous day. [day.
30	Mild to warm, damp & showery day. Nimbi more or less passing over all

Solar Halos on 1st, 3rd, 7th, 9th, 10th, 25th, 26th, 27th, 31st. Lunar Halos on 18th.

ERRATA.

In Part II. No. I. 1866.

Page 75, line 10, *for* Zebra *read* Zebu.
—— 75, —— 13, — Zebra —— Zebu.

// JOURNAL

OF THE

ASIATIC SOCIETY.

PART II.—PHYSICAL SCIENCE.

No. II.—1866.

*Russian Geographical Operations in Asia.—Communicated by Lieut.-Col. J. T. Walker, R. E.**

[Received 8th March, 1866.]

Translation of a Portion of the "Compte Rendu de la Société Impériale Géographique de Russie" for 1864.

The Society has never failed to profit by every opportunity that has presented itself, for extending our geographical knowledge of the countries bordering on Central Asia; consequently, in the month of February last year, M. Severstow, a distinguished Naturalist, who was accompanying an expedition into the countries beyond the Ili and the Tchon, was charged to collect information, with a view to preparing a physico-geographical description of all the countries through which the expedition would pass.

* Of the two accompanying papers, one is a translation of a portion of the "Compte Renda de la Société Impériale Géographique de Russie," for the year 1864, while the other is a translation from the 4th volume of the Journal of the Russian Geographical Society for 1864.

In the first the names are spelt as in the original French memoir.

The Society has just been enriched by highly interesting geographical materials, thanks to the cordial co-operation of its honorable members M. Milioutine, the Minister of War; M. Duhamal, the Governor-General of Eastern Siberia, and Admiral Boutakow.

We have been furnished with a very interesting manuscript chart prepared by the Staff Major. It represents, on a scale of 40 verstes (27 miles) to the inch, the southern portion of the Kirghiz Steppe, or, approximately speaking, the region between the Eastern shore of the sea of Aral, and the Chinese frontier, extending from 76° to 102° of longitude, and from 40° to 50° of latitude, and comprising the northern half of the district called Touran. On this map we have the result of all the geographical operations of the past few years represented for the first time. Until now they had remained isolated, and almost unknown to the scientific world. They greatly modify the general geographical aspect of this region. There are now determined a sufficient number of astronomical points to serve as a basis for an exact cartographic representation of the region above mentioned. We must observe, however, that the fixed astronomical points are as yet very irregularly distributed. They are comparatively numerous in the western part of the map, along the road from Orenburgh to the Syr-Daria, and along the lower course of that river, also along the Chinese frontier in the Eastern part of the map, but, about the middle, they are very sparsely scattered.

We now possess many orographic and hydrographic data, thanks to the military expeditions, and reconnoissances of 1864, and to the operations carried on for several years in the basin of the Syr-Daria by Admiral Boutakow. These data serve to correct the hitherto confused notions of the countries situated within and around this region. We have also received more accurate information regarding the races that people these countries, their mode of life, their migrations, the remains and traces of their ancient condition, and the possibility of their future civilization. We can here only point out the most salient geographical features of the mass of materials we have received, and of which the Society will avail itself for its future publications. The geographical position of all the region above mentioned will have to be considerably altered, more especially as to western Turkestan, and the Khanat of Khokan. For instance, Aouliéta, a town

of Khokan, ought to be shifted, on the map, half a degree towards the south, and one degree towards the east; the town of Turkestan at least a degree and a half towards the south, &c. Similar changes are equally necessary for many other points. The eastern part of this region is essentially mountainous. The principal chain of mountains is found to be a western branch of the Tiau Chan; its direction is from east to west from the lake Issik Koul, down to the lower course of the Syr-Daria; these mountains were vaguely known under the general name of Karataou. They may be divided into three groups, the chain of the Kentchi-Alataou, the chain called Alexandrowskaïa, and that of Kazikourt.

The Kentchi-Alataou consists of two parallel chains, which follow the northern bank of the Issik Koul; they are separated (on the east of the Issik Koul) from the Tian Chan by the Pass of Sari Tasch; their greatest height is 14,000 feet. From this range, a lower range trends in a north-western direction, separating the waters of the Ili from those of the Tchou.

The second group, the Alexandrowskaïa, or the Alataou-Kirghisnyh chain, whose summits are covered with perpetual snow, joins the first at the defile of Baoum, on the western extremity of the Issik-Koul; thence it stretches due west towards Aouliéta, separating the river Tchou from the river Talas; its greatest height is 15,000 feet. To the west of this chain, other hills, rising not higher than 5000 or 6000 feet, stretch as far as the Syr-Daria, following the direction of that river down to Djoulek, and forming, so to say, a prolongation of the Alexandrowskaïa chain. It is to these hills that the name of mount Karataou, which has been wrongly given to the whole system of mountains in this country, properly belongs.

Lastly, the third group forms the Kazikourt chain and lies to the south of the Alexandrowskaïa, from which it is separated by the basin of Talas. The Kazikourt mountains appear to be a continuation of the principal branch of the Tian Chan; winding along the southern bank of the Issik-Koul, they fill the territory of Khokan with their southern ramifications. The disposition of these chains of mountains fixes the watersheds of the basins of the Tchou and the Syr-Daria, the two principal valleys of this country, lying almost parallel to each other. The valley of the Syr-Daria trends, with many

windings, from the south-east to the north-west. The Tchou flows in the same direction. Conformably with the general disposition of the whole mountain system of this region, these great basins are much narrowed towards the east, near Issik Koul, where all the above mentioned ramifications of the Tian Chan are concentrated. It must be observed, that the predominant direction of these chains of mountains, not only in this country, but in all mountainous parts of Central Asia, is always to the north-east. We now have more accurate data concerning the course of the Tchou, especially about its various sources, also its relation to the Issik Koul, from which it does not take its source, but with which it is connected by its affluent, the little river of Koutemalda.

The central portion of the basin of the Syr-Daria has been explored in detail, and with much success, thanks to the expeditions made during many years by Admiral Boutakow, who has quite recently communicated to us the general results of his enquiries, but especially of his late explorations between Fort Perowsky, and the locality called Baïldir Tougai.

It is impossible to set forth here all the accumulated data of these countries of Central Asia, but seeing the interest that they excite, we must add a few more words about their population. It consists chiefly of nomadic Kirghises, and a rather restricted number of Khokans. Their mode of life and degree of civilization correspond with those of the Kirghises who inhabit the country north of the Syr-Daria and the river Tchou.

Their chief wealth consists in cattle, horses and camels. They also cultivate their land and sow wheat, barley and tobacco.

After the military expedition of 1862, a great part of these Kirghise wanderers, from beyond the Tchou, passed into our territory.

To retain these tribes in subjection, the Khokans constructed forts, called Kourgans, in great numbers. The four chief ones were Pichpek, Merké, Aouliéta, and Souzak. Aouliéta on the Talas (between the valley of the Tchou, and the chain of mountains which trend from Issik Koul towards the west) has an important position, for it is situated on the grand commercial road from Tachkend and Turkestan, towards the fortifications of Vernoï, Kouldja and Sémipalatinsk. It is by this road that the caravans come from the southern

regions of Central Asia to go to China, as well as to Russia. On a branch of this road, which stretches towards the north-west, at a junction of the roads of Orenbourgh, Troïtsk and Oufa, is situated the town of Turkestan which encloses within its walls a sacred edifice, the mosque built over the tomb of Azret Sultan.

Passing now to the topographical operations executed in these Kirghise steppes of Siberia, we will mention the surveys that were effected on the western borders of *China*, under the direction of Colonel Babkow. These operations embrace two distinct circles,—the northern parts of the Tarbagataï mountains, and the valley of the river Borokhoudzir. In the first of these circles, Captain Nifantiew of the Topographical Corps, surveyed the region that is bounded on the *west* by the road which crosses the Khabar Assou Pass, and by the course of the river Tamyrysk; on the *south*, by the chain of the Tarbagataï; on the *east*, by the line of the Chinese posts, and on the *north*, by the Kitchkiné Taou mountains, branches of the Manak, and of the Tarbagataï. This region includes an area of 5,270 square verstes.

In the country beyond the river Tchou, the topographers who formed part of the detachment with the expedition, surveyed the following localities. 1st, From the post of Kastek, by the pass of the same name, to the mouths of the little Kebin, and thence re-ascending the river Tchou, to the mouths of the great Kebin, then 40 verstes of the lower course of this last river. Then again, from the mouths of the little Kebin, along the river Tchou, to the ford of Tchoumitch. All these surveys have been mapped on a scale of 250 sagènes (or 1750 feet) to the inch. 2nd, From the river Talas, crossing mount Kara Boura, to the river Tchotkala (Tchirtchik). 3rd, The marching roads along the valley of the Arys, and those from Tchemkent to Aouliéta, also from Tcholak Kourgen to Aouliáta, have been drawn on the scale of 5 verstes to the inch. 4thly, Plans of the forts of Tokmak, Merke and Aouliéta have been drawn out, on a scale of 250 sagènes to the inch.

We have received from M. Bésac, the Aide-de-camp General, a map of the topographical operations, executed and projected in the country of Orenbourg, from the year 1861 to 1865, with a Memoir.

The total survey is 17,687 square verstes done in detail, and 3,928 in half detail; 168,178 reconnoitered, and 2[illegible],100 triangulated. During

a period of four years, the total amount of survey operations is 212,019 square verstes.

These surveys embrace the following localities; 1st, the two banks of the river Yany Daria; 2ndly, the left bank of the Syr-Daria, from the fort Perowsky to Yany Kourgan, a destroyed fortress belonging to the Khokans, and thence to the place called Baildyr Tougai; 4thly, the northern and southern slopes of the Karataou chain; 5thly, the mouths of the river Emba, and the Bay of the Caspian Sea at the mouth of this river. Among the newly made maps, the principal are, the map of the country of Orenbourg, on a scale of 50 verstes to the inch; a new map of Central Asia and the country of Orenbourg, 200 verstes to the inch; and 24 sheets of a special map of this country, on a scale of 10 verstes.

The Society is continuing the publication and translation of the 7th Vol. of Ritter's *Geography of eastern Touran*. M. Grigoriew is compiling and making the necessary additions for completing this work, and is carrying on his labours with such activity, that we may look for the first part of his work during 1865.

However short our account may seem of all the important geographical operations in Asia, it is nevertheless sufficient to show that they embrace a large extent of this part of the world, and give rise to questions of both local and general interest. The several expeditions and explorations, in which our Society has taken part, form an uninterrupted chain which extends along our Asiatic frontier, from the Pacific Ocean to the Caspian Sea; from the valley of the Oussouri and the peninsula of Corea to the Oust Ourt, Turkestan and Khorassan. With the exception of some conflicts with the Khokans, our enterprises along the frontier have been of a strictly peaceful, scientific or commercial character, and our commerce has been considerably developed. These friendly relations are strengthened by an event of great importance which marks the past year, viz., the final pacification of the Caucasus, the point of our Asiatic frontier that is nearest to Europe.

We must now pass on to the hydrographic operations executed in the Caspian Sea, which have always greatly interested our Society.

Last year, our honorable member, M. Ivachinzow, who is the chief of these operations, read out to the Society, at a public meeting,

a remarkable Memoir on the question of the variations of the level of the Caspian Sea. The same persons who carried on these hydrographic operations in 1863, continued them in 1864. At the beginning of the year, the Surveyors were concentrated in the southern parts of the sea, between Bakow and Lenkoran, a region bristling with rocks and volcanic islands. From January up to May, they explored and fixed the positions of several isolated volcanic reefs, which, as they undergo frequent change from the action of subterranean forces, often become very dangerous to navigators, and consequently require frequent soundings and examinations. The materials thus collected, regarding this volcanic region, may some day serve as valuable contributions towards the composition of a complete monograph of this extremity of the Caucasus.

In the month of May, the hydrographic expedition crossed over to the eastern shore, between Tub-Karagane and the gulf of Karabougaz. During the subsequent five months, an extent of more than 200 verstes was surveyed and sounded, chiefly between the isthmus of Manguich-lac and the gulf of Krasnovodsk, under the command of Lieut. Phillippow and Lieut. Dournew of the Pilot Corps. Soundings were also taken by Lieut. Oulsky, in the middle of the Caspian Sea, with an apparatus specially constructed for bringing up specimens of the different soils, and the fossil and animal life they contain.

In June and July Captain Phillipow's party explored the entrance to the gulf of Karabougaz. At the same time, Lieut. Staritzki made some interesting observations on the speed of an uninterrupted current of water directing its course through the Gulf towards the Sea.

The object of these observations was to determine the quantity of water which enters the gulf of Karabougaz, and the quantity of saline particles which is brought there. The exploration of the mouth of the Karabougaz will serve as a basis for a complete study of this interesting gulf. It is the opinion of M. Baer, the Academician, that this study will lead to a solution of the question regarding the variations of saltness in the Caspian Sea. No one will doubt the economical importance of this question, which is intimately connected with the future fisheries of the Caspian. The results of the hydrographic operations are developing gradually, and are partly published. In addition to the maps and plans of different parts of this sea

that have already appeared, a report of the astronomical and magnetic operations is being actually printed.

In speaking of the favourable results that have been obtained by the activity of our Society, we have not had the least intention to attribute it to one more than to another of its functionaries. Among us, individuals change and succeed each other so rapidly, that we cannot say the progress and strength of our institutions rest with them. It is the general conditions of our activity, and the liberal spirit by which they are pervaded, that unite and attract a constant succession of individual labourers. Besides the actual operations of the Society during the past 20 years, a vast amount of labour has been undertaken voluntarily, and without remuneration, by members of the Society, as well as by strangers, in private and in official capacities. Such are the public lectures, which many of our colleagues have delivered without any remuneration, and which have attracted large audiences to our reception Halls. We need not mention, in this place, the number of persons who, during the past and many preceding years, have disinterestedly brought accounts of their labours to the Society. It is doubtless through the liberal spirit which unites and animates all our members and constitutes our strength, that this great amount of work has been accomplished. Religiously to preserve this spirit should be our first duty, and our most sacred obligation.

Translation of a portion of the Journal of the Russian Geographical Society, Vol. iv. 1864.

At a meeting of the Society on the 2nd and 14th December, 1864, Rear Admiral *Boutakof read a paper on the subject of* his last exploration on the Syr-Daria, between Fort Perovski and Baïldyr-Tugai (a locality in the Tashkened territory). In 1863 Rear Admiral Boutakof steamed 538 miles up the Syr-Daria, from Fort Perovski. This officer has now explored, determined astronomically, and mapped 1003 miles of that river's course, beginning from its mouth. He expresses his conviction that the river is navigable still higher up, although, for want of fuel, he could not this time proceed further. The general ascending direction of the river from Fort Perovski is towards the south-east as far as the parallel of 43° of latitude; thence it is directly to the south. Throughout the whole distance of 538 miles,

from Baildyr-Tugai to fort Perovski, the river flows in a magnificent mass of water between depressed banks of an argilo-salinous and sandy character, for the most part inundated at high water; there was nowhere either a *break* in the banks, or a stone, for the observation of the geologist. The swamps, after the subsiding of the waters, afford excellent pasturage whereon numerous Aouls of Kirghizes settle for the winter. In the midst of these meadow patches there occur here and there like *islands*, sand hillocks differing in height, from 30 to 40 feet, and overgrown with tamarisk, &c. The dry argilo-salinous banks rise from 7 to 10 feet above the level of high water, and are covered with tamarisk bushes with thorn (growing high and thick), and in some places with the "Turanga" and "Djida." Nearer to our own possessions, large tracts are covered with the "Saxaul." Vegetation is most abundant on the islands, many of which are two miles long. Upon these the "Djida" grows 4 fathoms high, and the thickness of the "Turanga" reaches 10 inches in diameter. Almost all the islands are covered with a dense, almost impassable brushwood; where the Kirghizes declare there are tigers, drawn thither in pursuit of wild boars. The breadth of the river is from 150 to 400 fathoms; the depth from 3 to 5 and 6 fathoms; the current ran at a speed of 7 verstes (4⅔ miles) an hour, the average being from 4½ to 6 verstes (3 or 4 miles); the water was of a dirty yellow colour, but when allowed to settle, was very soft and agreeable to the taste. Admiral Boutakof found no evidences of a settled life throughout the whole of the river's course. Patches of soil, cultivated by the poorest of the Kirghizes, occurred at extremely rare intervals; and these were irrigated by water from canals replenished by hand from the river. The Kirghizes generally sow millet, sometimes barley, water-melons, and musk melons in their fields. There are two principal reasons for the absence of population along the banks of this river: firstly, the absolute want of any guarantee for personal security and for the protection of property and labour in the face of perpetual disturbances in Turkestan, Tashkend and Khokan; and secondly, the greater advantage of settling along the rivulets running from the Kara-tau mountains; these afford better facilities for irrigation than the Syr-Daria, which inundates and washes away its banks, and consequently demands an enormous amount of labour for the construction and maintenance of the necessary

embankments. This splendid water-course, navigable to Fort Djulek (the extreme eastern fort on the Syr-Daria line of frontier) which would be a picturesque feature in any other place, is surrounded by a bleak desert, and is now only occasionally enlivened by migrating hordes of Kirghizes, whereas the remains of the ancient towns of Otrar (where Tamerlane died) and of Tunent (destroyed by Tamerlane) which were seen by Admiral Boutakof, and the traces of a once extensive system of irrigation surrounding the ruins of these places, and occurring also in many other parts, are evidences of a once numerous, industrious, and settled population. The shores of the Syr-Daria, above and below Fort Djulek, present a striking contrast. Above Djulek is a howling desert; below, and particularly commencing from Fort Perovski, all is life and activity along the banks. Corn fields and melon fields occur continually, with populous Aouls of well-appointed tents, animated by the presence of herds of cattle. The Kirghizes assemble by hundreds to dig fresh canals for irrigation. Vast tracts of swamp and reeds, which were impassable in 1848, have been protected by embankments against the overflowing of the river and converted into corn fields which now engage the labour of thousands: and all this is exclusive of the localities within 50 or 100 miles of our Forts, especially the neighbourhood of Fort No. 1, where, in the excellent gardens surrounding the Cossack settlements, grapes are grown, and cotton has been sown not without success. Kirghizes and sometimes Karakalpaks constantly migrate from the Khivan territories to the lands under Russian protection, so that they at length find themselves cramped for space. The Khivan and Khokandian forts which stood on the grounds now occupied by the Russians, were the centres of the most merciless and barbarous persecution. The Russian forts, on the other hand, are now guarantees for security, and serve to promote traffic and the general well-being of the natives.

The advent of the Russians did certainly produce a most beneficial crisis in the condition of the Kirghizes of the Syr-Daria.

Within 8 miles of Baildyr-Tugai, Admiral Boutakof's highest limit of ascent, there are the ruins of a small Khokandian fort, Bair-Kurgan, demolished, according to Kirghiz tradition, about 100 years ago. At a distance of 40 miles higher up, on the left bank, are the remains of the town of Tunkat (rased by Tamerlane). This place is

now called Tskilleh, after a saint of that name whose tomb is close by.

There are more Kirghizes grouped about Tunkat than over the entire extent of country traversed by Admiral Boutakof; and to all appearances these were opulent, being possessed of immense studs of horses and camels, and of droves of horned cattle and sheep. Above that place, *i. e.* nearer to Tashkend, he fell in with two rich migrating Aouls, one encamped by the side of the river.

Descending the Syr towards the river Arys, an open space becomes visible beyond the zone of reeds, at 4 or 5 miles from the river, studded with clayey sand mounds that are covered with a scanty and low brushwood. Some of these mounds are evidently artificial. On a sort of tableland, within 7 miles in a direct line, and almost due north from the mouth of the Arys, are seen the remains of what may have been the citadel of the ancient town of Otrar.

From the mouth of the Arys to the little fort of Utch-Kayuk, abandoned two or three years ago by the Khokandians, and built on a marshy soil, the distance is 84⅜ miles. The character of the river here is still the same, the same bends and islands, the same depressed banks, mostly flooded, the same vegetation along the shores and on the islands. The forts Utch-Kayuk, Din-Kurgaon, Yang-Kurgaon, Djulek and Ak-Mechet, (now fort Perovski), Kumysh-Kurgaon, Chin-Kurgaon, and Kash-Kurgaon (the three latter below fort Perovski,) were the rallying points of the Khokandians, for the subjugation of the Kirghizes, and the centres for the collection of tribute and the general merciless oppression of that people. Yang-Kurgaon, raised by the Khokandians in 1857, and Din-Kurgaon, erected in 1860, were the last points of Khokandian resistance against the spread of Russian influence; here also the last attempts were made by the Khokandians to retain under their yoke the Kirghizes who passed over in masses to place themselves under our protection. Yang-Kurgaon fell in 1860 to the Russian arms; Din-Kurgaon in 1861. Utch-Kayuk is the nearest place to the town of Turkestan; it was visible from the river, being situated in a hollow of the foreland of the Kara-tau mountains.

The only affluents of the Syr seen by Admiral Boutakof are the rivers Arys and Sauran-Su, falling into the Syr on its right bank

opposite the An-djar settlement, 8⅜ miles below Utch-Kayuk; other rivers emerge from the Kara-tau mountains, namely the Tuitchke whereon Turkestan is situated, the Karaichik, 6 miles lower down, and the Sart-Su; these do not reach the Syr-Daria, but lose themselves in the marshes formed by its inundations.

Below Utch-Kayuk the country at first is inundated, and large wet meadows, or more correctly morasses, extend along both banks of the river, but further on, especially on the right bank, land is firmer.

Nearer Djulek the trees on the banks are higher and thicker than along the whole remaining portion of the river's course. In the immediate vicinity of this Fort, there is a very pretty avenue of tall and thick willows, looked upon by the Kirghizes as a sanctuary (Aulie).

Between Djulek and fort Perovski the banks are generally firm and salinous, but not elevated. The "Saxaul" is very abundant at the Kasakty-Syra, Chagonon and Kushsant settlements, and opposite Burinbai. The islands and the continuing banks are covered with the "djida," "turanga," and occasionally with willows, and the margins are usually clothed with high dense thorn and reeds. Sandy hillocks occur beyond the saline plains, and in many places Kirghiz tombs and the remains of long neglected irrigating canals are met with.

From the 14th July, when the expedition was proceeding upwards and was within 67 miles of Utch-Kayuk, the waters were visibly subsiding, and daily decreased, though the heat continued to be great, up to 30° R. in the shade. This was doubtless owing to the exhaustion of the supply of snow which accumulates on the mountains, where the river takes its rise. At fort Perovski the water began to fall only from the 30th of July, and at Fort No. 2 from the 5th of of August (N. S).

Notwithstanding that Admiral Boutakof's expedition had to halt at night close to marshy lands, there were no cases of ague, and so far as he was able to judge, the climate on the Syr-Daria, in its upper as in its lower course, was healthy. His astronomical observations disclose great inaccuracies in this portion of the map of Central Asia which is founded on the determinations by the Persian Missionaries of the 18th century.

The communication made by Admiral Boutakof, who has long distinguished himself by many years of labour in this region, was listened to with great attention, and received with great enthusiasm. We could not give here more than the mere outlines of the paper, which he is now preparing for the press, and which will appear with a map of the Syr-Daria. There is no doubt that Admiral Boutakof's work will be an agreeable acquisition for modern geographers.

Kashmir, the Western Himalaya and the Afghan Mountains, a geological paper by Albert M. Verchère, *Esq., Bengal Medical Service; with a note on the fossils by* M. Edouard de Verneuil, *Membre de l' Académie des Sciences, Paris.*

[Received 11th March, 1865.]

Introduction.

Of all the great chains of mountains on our Planet, the most stupendous is, singularly enough, the least known to the geologist. Many fossils have indeed been collected by travellers in the Himalaya, and a few have been determined; but satisfactory sections and careful descriptions are very scarce, and it has not yet been found practicable to attempt any general grouping and arrangement of the rocks and beds of these mountains. Jacquemont's researches in Kashmir have not, I believe, much advanced our knowledge of the geology of the country. Mr. Vigne was no geologist, and his observations were not sufficiently accurate for scientific purposes; the same remarks apply, more or less, to most visitors who have published what they saw amongst the higher ranges. Captain R. Strachey, R. E. in his papers on the geology of the Himalaya, between the Sutlej and the Kali rivers, gives a map and two sections which are of great interest; they do not, however, refer to the portion of the Himalaya which I have studied, and they leave yet a vast field for more precise investigations. I regret not having been able to consult Capt. H. Strachey's paper

on the physical geography of Little Thibet, and Dr. Thompson's work on the same country; neither have I had the benefit of Mr. Medlicott's Memoir on the southern ranges of the Himalaya, between the rivers Ganges and Ravee, nor any of the other papers which have been written on the Sub-Himalayan ranges.

Of the geology of Kashmir especially, I believe that very little indeed has ever been published, and that not even a geological horizon has been discovered. Mr. Vigne and Dr. A. Fleming reported having found in Kashmir "Nummulitic limestone disturbed and calcined by greenstone;" this was an error of some importance, as it gave a false datum from which to fix the age and relations of the Azoic rocks. Dr. A. Fleming, in his report on the Geological Structure of the Salt Range, published in Selections from Public Correspondence of the Punjab Administration, Vol. II., 1855, has the following passage:—

"From Kashmir, too, Mr. Vigne obtained limestone *containing* "*nummulites*. This we have seen in situ on the side of a mountain "at the upper end of the Manus Bal lake, where it is much disturbed "and calcined by greenstone. It probably forms the summit of "many of the higher hills on the northern side of the Kashmir valley, "a district fraught with interest to the geologist and hitherto quite "unexplored."

When I arrived at Srinuggur, Mr. Drew, who had visited Manus Bal, showed me some specimens of the limestone of that locality, and expressed a doubt about the markings seen on the rock being nummulites; he considered their markings to be the result of crystallisation and weathering; but I could not accept this view, and regarded the little marks as indications of organisms. I was unwilling to believe that Dr. A. Fleming could possibly have made a mistake about nummulites, after the experience he had had of their appearances in the Salt Range and the Bunnoo district; and, as Mr. Drew acknowledged that he was not familiar with the nummulitic formation, and the specimens shown me were very bad and ill-preserved, indeed merely faint marks in a coarse limestone, I temporarily admitted Dr. Fleming's view. I was, at the time, unable to visit Manus Bal, or to absent myself a single day from Srinuggur, owing to great sickness amongst the visitors; but I had the good luck to discover a bed of fossiliferous limestone and shales within a few miles of

Srinuggur. These beds were near enough to enable me to ride to them in a few hours, and I soon found that they contained the same forms as were known to occur in the dressed blocks of limestone (obtained from Buddhist ruins) of which the river-walls and river-stairs of Srinuggur are built, and I also found the remains of one of the antique quarries near my favourite locality. Ultimately, the rocks reported to be nummulitic were found to be carboniferous, and the so-called nummulites, rings of Encrinite-stems; the volcanic rocks were also ascertained to be palæozoic in age and not intrusive. (See para. 53, where the Manus Bal limestone is described in detail.)

To my friend, Captain Godwin-Austen of the great Trigonometrical Survey, I owe my best thanks. I had wished that this paper might have been written in conjunction with that gentleman, and it would have been well for the reader, if it had been so; but as Capt. Austen went to Bhotan and I to Bunnoo, such a hope had to be abandoned.

In drawing up the map, I have used for its topography whatever materials I could procure, but I have not had the benefit of many recent discoveries and surveys. The compilation was made from works of very different values. Kashmir, Hazara and the British Trans-Indus districts are, I believe, tolerably accurate; the Salt Range is less so; whilst the Korakoram Chain, the Hindoo Koosh, Kaffiristan, Chitral, Kabul, etc. only lay claim to give a general outline and direction of the ranges, valleys and rivers. About the Hindoo Koosh, I much regret not having been able to avail myself of the maps of Kaffirstan lately published in the office of the Surveyor General of India.

It may appear, on seeing how little of the Afghan mountains is geologically coloured, that there was no necessity of extending the map as far as the Hindoo Koosh, but I hope that the advisability of having sketched in this chain will be acknowledged, after reading the fourth chapter of this memoir.

The geology of the map is partly from my own observations and partly from information obtained from friends and travellers; I have endeavoured to enter nothing which did not appear pretty certain. I have been able to sift satisfactorily a good deal of the information obtained, by means of specimens which were either shown or given to me.

I have added a few sketches of fossils which, I hope, will be found sufficiently well done to enable the organisms to be easily recognized. The forms sketched are those which have appeared to me most characteristic of the beds met with.

The two parts of which this paper consists are nearly separate memoirs. In the first, chapters 1 and 2, a description of the mountains of Kashmir is given in some detail. In the second theoretical views are discussed; but as Kashmir is merely a small portion of the Himalaya, it was found impossible to understand many fossils without taking such general views as referred to the whole mass of the chain; and, further, as the Himalayan chain is supposed by me to be intimately connected with the Afghan mountains, these mountains had also to be considered. In order to be intelligible, it became therefore necessary to write a cursory survey of the Afghan-Himalayan regions; this is done in the 3rd chapter. It is of course very superficial and incomplete; yet I hope that it may not be without some interest. On the data furnished by the first three chapters, the hypotheses advanced in the fourth are based.

I have not entered into many details on the eocene and miocene formations (except incidentally), as it would have lengthened to undue proportion this already too long paper; these formations deserve to be studied by themselves. The same remarks apply to the Jurassic and Saliferian rocks. In chapter 3, however, a few words will be found on the nature and relations of these beds. The principal object of this paper, in its descriptive portion at least, has been a study of the older rocks, viz. Silurian and carboniferous, together with the volcanic and metamorphic rocks.

I trust that the many imperfections and errors which cannot fail to occur in a memoir of this nature, will not be too severely criticised. My excuse is that this paper was prepared at one of the out-posts of the Punjab Frontier, where I had not the usual assistance of a Museum and a Library. Such as it is, I hope that it may not be without interest to some of the members of the Society who are fond of geological researches.

Chapter I.—*Felstone and Porphyry.*

The mountains South-West, South and West of Cashmir.

Baramoola is a small city, well known to the tourist in Cashmir and to the pedestrian coming from Murree; it is a haven of rest, for here boats may be hired to take him to Srinagar, the very heart of the valley. From the heights above the town the traveller gets his first view of the celebrated vale, and in the spring of the year it is difficult to imagine any more beautiful landscape than it affords. It is here also that disappointment or enthusiasm commences, according to the traveller's disposition: for to many Cashmir is an overrated land, whilst to the scientific man, to the artist or the antiquarian it is a mine of great wealth.

The town is built at the foot of a hill which has a direction west to east, and is cut in two to give a passage to the river Jheelum. It is approximatively in N. Latitude 31° 13′ and E. Longitude 74° 23′. Its southern view is limited by a small hill, the Atala, and on the west a mountain of 8,467 feet, the Shumalarum, also confines the horizon. Thus, placed in a cradle of hills, on the banks of the Vedusta, it has a picturesque aspect, a damp cold climate, a celebrity for rain and storms, and a great name for earthquakes.

The hills at the foot of which Baramoola is built are the extreme eastern extension of the great Kaj Nag Range, which, proceeding from E. to W. for 20 miles, bifurcates into a huge north-westerly branch (which I shall leave alone for the present, as I know nothing about it), and a southern branch which, proceeding S. S. W., divides again, one arm going west towards Mozofferabad, whilst the other, the Kiren or Kirna range, crosses the river at Ori (or rather the river crosses it) to be continued with the Kandi range in the direction of the Pir Punjal chain.

2. The whole range of hills near Baramoola dips S. by a few degrees E., and in describing the rocks from S. E. to N. W., we shall therefore proceed from the more superficial to the deepest.

On the left bank of the river, we find a clinkstone or felstone of a dark grey colour and slaty texture, and an appearance as if it had been drawn while in a viscid state. It has a sandy feel to the hand; it breaks into long narrow flags having a close resemblance to pieces of

pine wood which have been cut and prepared for burning, and have weathered grey by exposure. It has a well marked stratification, which is cut obliquely to its plane by a slaty cleavage which forms with it an angle of about 113°. It has also a series of parallel joints, about 2 or 3 feet apart, and which cut the stratification at right angles but form with the cleavage an angle of 67°. The joints are usually lined by a coating of quartzite, and both quartzite and felstone are occasionally stained by iron.

The felstone appears to be entirely composed of elongated and flattened granules of felspar or albite, which has a sub-vitreous lustre when closely examined; it has a dark bluish-grey colour, but weathers ash-grey and even dirty white and some pieces which are very fissile, assume somewhat the silky appearance of amiánthus. The colour of the paste appears to be due to augite; this, by decomposition, lets free a certain quantity of iron which causes the surfaces of cleavage and stratification to be covered by a powdery, rusty incrustation. Sparingly disseminated in the mass are seen minute fusiform nodules of dark shining augite; these nodules are never crystalline. Some strata are extremely thin-bedded, like sheets of paper, and fall to pieces very easily, ultimately decomposing into a brownish earth. Other strata present an alternation of very thin laminæ of nearly white and dull albite, and a dark grey shining mixture of felspar and augite, so that, when the rock is broken vertically, it appears striped white and grey.

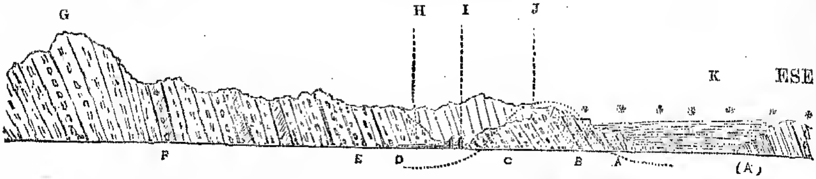
3. The above beds dip S. and a few degrees E., with an angle of 60° near the Atala hill, but the angle diminishes as we go towards the N. W., being no more than 45°, near the river at Baramoola. For two miles along the left bank of the Jheelum, this felstone was observed with, here and there, a band of amygdaloid interbedded. But I made too superficial an examination of the Atala to enter here into detail. Crossing the river to the right bank, we find that felstone also forms the hills which overhang Baramoola. Just over the city, it is similar to that of Atala, but as we proceed towards the N. W. and therefore see deeper beds, the character of the beds changes considerably. There is a beginning of separation of the minerals of the felstone, the dull white albite forming by itself innumerable penicilli having the shape of extremely elongated spindles which are imbedded in the grey felspathic paste. The rock has still,

however, a well marked stratification which is rendered very conspicuous by the white penicilli being parallel to it. There are also cleavage and joints as before, but a great deal more quartz in the latter.

The next beds, lower down, are much lighter in colour and more compact in structure. The paste is ash-grey, felspathic and dull looking, but instead of the penicilli noted before, we have here regular almond-shaped masses of white saccharine albite, usually about one inch long and two-tenths of an inch across, but often made larger and with the albite in the state of a fine incoherent sand. Then rocks, like the one with penicilli, but bluer in tint and interbedded with amygdaloidal greenstone and felspathic ash, containing oval nodules of augite, extend to the west, as far as the Shumalarum which they appear to entirely compose.

The angle of dip, on the right bank of the river, is again very great, being about 60°, and the beds are a good deal faulted. One fault has a direction N. E.—S. W. and the river runs in it at Baramoola. It is continued in a ravine on the right bank of the river, about a mile below the town. The angle of dip is not the same on both sides of the fault, and there has been a slight down-throw on the south. The Jheelum, while in the fault, is narrow but navigable; at the ravine, it turns suddenly to the south, quitting the fault and passing over a band of rock which stretches from W. to E., thus forming a small rapid. From this place to Ori, where the Jheelum enters the Sub-Himalayan tertiary sandstones, the Vedusta follows its course across the much up-tilted beds of felstone, changing its character of a winding, placid, broad and shallow river into that of a boiling, rapid, deep and narrow torrent, and forming, as it were, a succession of small falls and cascades all the way down. The thickness of the felstone near Baramoola is enormous. I can form but a mere appreciation, not having followed the beds sufficiently far to the west; but I am certain that it is much above 5,000 feet.

4. The following section (marked I. on the map) is merely a diagram to enable the reader to understand the position of the beds. It is oblique and not at right angle to the dip.



A. Dark grey felstone, slaty, stratified and with a cleavage and joints. Fusiform, elongated, minute granules of augite. Many thin-bedded strata, ... about 400 feet.

B. Felstone like A, interbedded with strata of felspathic ash containing nodules of augite, ... 30 „

C. Rough trachytic clinkstone or felstone, breaking in elongated slabs terminated by oblique, clean joints generally lined with quartzite, ... 500 „

D. Bluish grey felspathic paste with innumerable penicilli of white powdery albite,.. 500 „

E. Pale grey felspathic paste with almond-shaped masses of albite, either powdery or compact and saccharine. Beds of ash interstratified, ... 400 „

F. A succession of beds similar to D. and E. interstratified with bands of amygdaloid and of felspathose ash containing oval nodules of augite. This rock appears to form the whole of the Shumalarum, and was seen, as far as I could see, towards the west.

G. Shumalurum, 8467 ft.

H. River Jheelum or Vedusta.

I. Baramoola.

J. The dotted line is the Atala.

K. Lacustrine Clay and Boulders.

5. The rocks, which I have endeavoured to describe, are continued along both banks of the Jheelum as far as the fort of Ori, about twenty five miles south of Baramoola. Following them on the left bank, (Murree Road) we first cross the Atala, and can observe, near the village of Mihrur, very fine narrow slabs of felstone, twelve feet long, used as rafters to support a roof over a holy well or spring. Proceeding S. W. we cross a small marshy valley, and near the village of Ghaut Mullah we meet a succession of spurs directed towards the N. W., and which are the extreme north-western extension of the Pir Punjal Chain. These spurs are also made up completely of felspathic flagstone, identical to that which I have described above, but the dip and strike of the beds are different from that of the beds near Baramoola: the dip is W. with a

very high angle; but the rock is much decomposed, the vegetation rich, and little is seen until we reach Nansherra. Thence, the beds are well exposed, forming lofty cliffs over the path, of a grand and picturesque aspect; they are often quite vertical and seldom form an angle with the horizon of less than 85°. But the same force which has made those strata stand on end, has also broken them and wheeled round enormous sections of the beds. Even a superficial examination shows that portions of the hills, some thousands of yards long, caught as it were between two faults and thus set free in their movements, have been made to rotate on themselves, the strike changing its direction from a few to ninety degrees. Thus, near Buniar, the strike is N.—S.; a little further south it is W.—E.; four miles before we get to Ori it is W. 15° N.—E. 15° S. and the dip is southern and only 45°. At Ori the strike is again about N. W.—S. E. and the dip northern and 80°. But it is often difficult to see the stratification in these laminated rocks, as cleavages and joints are generally better marked than the stratification. The general strike, however, is from N. a few degrees W., to S. a few degrees E., and the dip is northern.

Between Nansherra and Ori, the felstone presents several appearances. The bulk of the hills is made up of a pale grey and extremely laminated felstone, having much the appearance of slate, and being crossed by numerous veins of opaque quartz. These veins are sometimes so thick that they form bands of quartzite. Near Ori, some beds are seen having the appearance of metamorphic chloritic slates. Others are made up of very thin-bedded felstone of an earthy appearance, and are wonderfully wavy and crimpled, whilst the beds above and below them are but gently undulated. It appears probable that these thin-bedded layers were deposited by water during periods of volcanic inaction, and that when the covering felstone contracted in cooling, the aqueous deposit was gathered in zigzag folds. They ought, therefore, to be considered either as an ash arranged by water, or as a laterite derived from the surface of decomposing felstone, and having the same composition as its parent rock.

6. About half-way between Buniar and Ori, is a small Buddhist ruin concealed by brambles and wild roses, and built of a dark grey rough trachy-dolerite. This rock was obtained from a thick band

which is well seen close to the ruin. It is divided into somewhat prismatic blocks by joints; it is generally compact, but sometimes scoriaceous, and it appears to have had some influence on the cooling of the felstone above and below it, this being much more compact near the trachy-dolerite, and becoming gradually more laminated and slaty as we get further off. I cannot say whether the trachy-dolerite is intrusive, or interbedded; but it is perfectly conformable to the felstone.

7. At Ori, we find a small valley sunk between high mountains and crossed by a tolerably big ravine and by a torrent flowing from the S. E. to N. W. This torrent divides the hills on the S. W. which are miocene sandstones and shales, from the mountains on the E. and N. E. which are volcanic. The Jheelum describes a semi-circle round the extremity of the Kiren range, the beds of which cross the river to be continued with those of the Kandi or Kanda Range, which are the link between the Kirna Range and the Pir Punjal Chain. The river runs for a little while between the volcanic rocks of the Kirna and the miocene sandstones, but it very soon leaves this bed, and cutting a canal through the tertiary sandstones and clays, bids farewell for ever to rocks of a volcanic origin.

8. I will not enter into a description of the tertiaries in this paper, though we shall have to see much of them incidentally, but as it has been said and written by many persons that the miocene sandstones and clays dip under the volcanic felstone (generally described as metamorphic schists or quartzose mica-slate), I must correct the error, while we are at Ori. Both the volcanic and miocene beds are nearly vertical, but not quite, and dip northernly, and there is therefore an appearance of the miocene dipping under the felstone. On examining the high bank of the Jheelum, however, not far from the fort, I could see the miocene beds bend backwards, thus showing that they

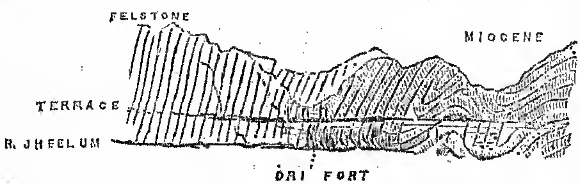


fig. 1.

are superior to the volcanic rocks, but have been dressed up against them by a lateral pressure. The diagram (fig. 1.) shows well the folded

disposition of the miocene and the bending backwards of the beds in contact with the felstone. These beds are partially concealed by a very high river-terrace of conglomerate, but this has been washed off in many places and the rocks are left uncovered.

There is, in the Sub-Himalaya, sufficient evidence of miocene sandstone having been mostly raised by a lateral movement; there appears to have been a reflection, a *refoulement* of the miocene beds towards the S. and the W., as if the enormous masses of the central chains had surged up through a chasm of the earth's crust and forced the sandstone aside, instead of lifting it up. And thus the volcanic rock of my diagram would have pressed against the miocene, and curbed up and bent back the yielding plastic beds of sandstone and clay.

9. Returning now to Buniar, half way between Ori and Baramoola, we cannot fail to admire the remains of a Buddhist temple of considerable size and great beauty. It is built of a white porphyry, and of this porphyry we must now speak in detail.

The stones of the temple were obtained from huge blocks which are strewed on the river terraces on both sides of the Jheelum, in the neighbourhood of Buniar. Some of these blocks are of enormous size: one I noticed is about 20 feet above ground and nearly as thick and broad as it is high. No water-power could have moved such enormous masses, and they have evidently been brought down by glaciers. I have been told that Mr. Vigne supposed them to have been brought by icebergs floating on a huge Kashmir lake, but we need not go so far for their origin, as the Kaj Nag peaks, seven miles to the north, and the Sank or Sallar, eight miles to the south, are mostly composed of this porphyry. A glance at the map will easily demonstrate how glaciers, filling up the narrow valleys of the Harpeykai and the Khar Khol, brought down to the river-terraces blocks of porphyry detached from the summits of Kaj Nag and Sallar (13,446 ft. and 12,517 ft.). I had not time to visit these valleys and look for ancient moraines, but some blocks show striæ and scratches such as glaciers alone can produce. These glaciers no longer exist, but their disappearance is only the result of a change of climate of the Himalaya, which is abundantly proved to have taken place at a very late

geological epoch by the river-terraces, raised lacustrine deposits and other indications of diminished rain-fall.*

10. Examining the porphyry of the Kaj Nag mountains in hand specimens, we find it composed of the following minerals:—

a.—Paste of granular, white, opaque albite, fusing before the blowpipe without much difficulty or = $4\frac{1}{2}$ of Von Kobell's scale of fusibility.

b.—Small transparent crystals of quartz-like rock-crystals.

c.—Large crystals of glassy shining albite, with a vitreous lustre and a lamellar cleavage. Sections of the crystals are sometimes as much as five inches long.

d.—Plates of white mica; sometimes grey.

e.—Dark augite (or Horneblende ?) with an Iodine lustre and a dark greenish grey colour. It fuses = 4, without swelling or boiling.

f.—Garnets; red, brittle and cracked.

g.—Grains of magnetic iron ore; metallic lustre; black.

h.—Gold; in invisible scales.

The paste of granular albite is hardly to be seen in the most crystalline specimens of the porphyry; but it increases very much as the several crystals are less abundant and less well defined, forming rocks in which we see, beside it, only a few specks of dark augite and spangles of white mica; even these occasionally disappear, and we have a rock having a saccharine appearance, and entirely composed of minute shining grains of albite. Specimens are found in all the stages of transition, from the highly crystallized porphyry to the saccharine rock.

The quartz is not very abundant in the most perfect porphyry, but it increases in some specimens, rows of small rock crystals appear-

* The diminished rain-fall is the result of the filling up with diluvial deposits of the great troughs situated between the Himalaya, the Affghan mountains and the mountains of Central India once covered by the sea, and now represented by the valleys of the Ganges and Indus. This filling up of the sea-communication once existing between the Bay of Bengal and the Arabian Sea, converted the Himalaya's climate, then insular, or at least littoral, to an eminently continental one. The tremendous rain-fall at Cherra-Poonjee ($50\frac{1}{2}$ feet during S. W. Monsoons) enables us to form an idea of what the snow-fall must have been on the high summits of the Himalaya in the days when the Bay of Bengal extended to the foot of the Siwalik hills, and the Arabian Sea bathed the Salt Range.

ing in the map. It becomes also amorphous and forms bands of considerable thickness of opaque quartzite, crossing the rocks in the same manner as similar bands often cross beds of shales or other stratified rocks.

The mica is also scarce in some specimens, small spangles being occasionally imbedded in the substance of the large crystals of albite (c) or sparingly disseminated in the paste. But in other portions of the porphyry it becomes very abundant, forming tufts of plates which resist decomposition better than the other minerals, and stick out of the rock where this has been worn and rounded by exposure. These tufts of mica often form irregular bands.

The augite varies from a few specks to laminar masses of considerable size. It is often found associated with felspar alone, the other minerals having disappeared, and it thus forms a rock composed of amorphous grains of albite and lamellar masses of augite. Before the blowpipe it fuses only in places, small globules of a shining black glass appearing on the assay.

The garnets are sometimes wholly wanting and sometimes very abundant. It is very difficult to extract them from the mass, owing to their brittleness. They are mostly found where the porphyry is well crystallized and the mica abundant.

The large crystals of albite vary in size from half an inch to five inches. They have two cleavages, one nearly at a right angle to the surface of the plate, or forming with it an angle of about 95°. The other cuts the first cleavage obliquely with an angle of about 115°.* The form of the crystals is, I fancy, uncommon, and I will describe one of them with its dimensions, in order to give an idea of the proportions of the crystals.

The crystal is always twin or composed of two hexagonal plates (fig. 2) two and half inches in diameter between opposite angles, and 0.4 inch thick. Either four or the six edges of the plate are bevelled by oblique facettes, which form with the plane of the surface an angle of about 138°, so that one surface is considerably smaller

* The angles of these crystals were measured with strips of paper and a graduated half circle; the crystals were also much weathered; the results are therefore mere approximations. If I had had the means of measuring the angles with precision, I would have figured the crystals.

than the other. Two such plates are applied one against the other by their greatest surface, but one of the plates has (apparently) rotated half a turn, so that A of one plate is opposite B of the other.

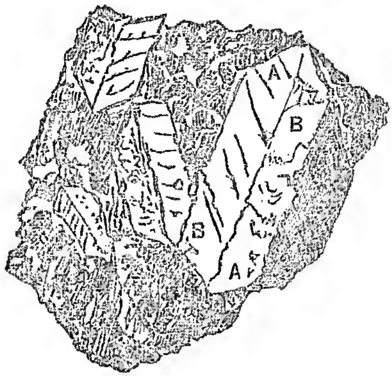


Fig. 2.

This rotation is of course only apparent, but it appears to have taken place from the cleavage of the two plates being opposite, so that when we look at a section of the double crystal (fig. 2), one side presents the shining striped surface of a lamellar cleavage, whilst the other shows the dull rough surface of a fracture across the grain. This opposition of cleavage is probably due to a play of opposite electricity generated during crystallization, but it gives the idea of one of the plates having made half a turn before applying itself against its fellow.

The perfect crystal is rarely seen; it is generally broken across, and the section (fig. 2) is conspicuous on the surface of the rock, so that, at first sight, one may fancy the crystals to be prisms, and a little trouble is necessary to understand the arrangement of the twin plates. This macle is therefore, to all appearance, a twin crystal of one of the numerous modifications of triclinic albite.

By exposure to the atmosphere, the porphyry crumbles easily and falls to a coarse gravel which is soon converted into a very white sand. While the rock is still hard and sound, the large crystals

of albite sometimes become loosened in their matrices, and, falling out, leave angular cavities on the face of the rock. The rock, when fresh and well crystallized, is however very hard: some varieties appear to crumble much more quickly and completely than others.

II.—The grains of magnetic iron ore and the gold I have not seen in the porphyry,* but they are found in the sands which, I will now endeavour to prove, have been formed by the decomposition of these volcanic rocks.

Gold is washed in most of the rivers which traverse the miocene sandstones and conglomerates of the sub-Himalaya, and is always found associated with grains of magnetic iron ore. Let us examine one of the districts where the washings are, I believe, most abundant, the banks of the Soane river, in the districts of Jheelum and Rawul Pindee, especially near the villages of Pindeh Geb, Kothair and Mukud. Let us therefore go to Rawul Pindee and travel towards the S. W. along the road to Kalabagh. We find that this dreary road, about 120 miles long, crosses obliquely from the N. N. E. to the S. S. W. the great plateau of miocene sandstone, conglomerate and clay (Sect. G.).

There is a thick bed of miocene sandstone and conglomerate, above 2,000 feet thick, which might be called the upper miocene formation of the Sub-Himalaya (contemporary of the Sewalik hills and containing the same Mammalian fossils), whilst the sandstone and shales of Murree and adjacent hills, about 5,000 feet thick and without fossils, might be regarded as the inferior miocene. These two divisions of the miocene are not exactly one on the top of the other, but rather the upper bed thinning towards the north, covers in the southern edge of the lower bed in an intricated

* A similar granitoid porphyry exists in Portugal, in the hills near Cintra about five leagues from Lisbon. It is there very variable in appearance and consistency, and is generally made up of large grains of felspar and of quartz, and of large plates of mica. It contains grains of magnetic iron ore, but I am not aware whether it contains the large twin crystals of felspars seen in the Kaj Nag porphyry. The Portugal rock is generally described by travellers as granite, but is considered by geologists as decidedly volcanic. It presents the character of crumbling easily after a certain amount of exposure.

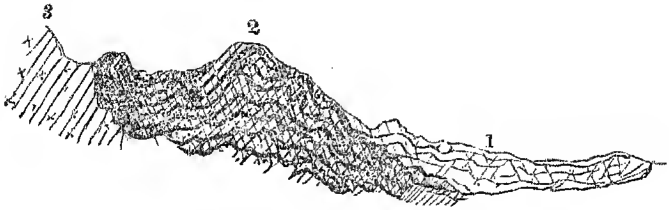


Fig. 3.

manner, as represented in the accompanying diagram (fig. 3) : 1, Upper Miocene with Mammalian Bones; 2, Lower Miocene without fossils (excepting a few roots and stems and imprints of leaves) ; 3, Porphyry and Felstone, &c.

The upper bed is therefore not seen near Murree, whilst the lower bed is equally absent from the great plateau of Rawul Pindee, where the fossiliferous sandstone is always seen to rest directly on the Nummulitic formation, wherever this breaks through the miocene. The bed we have to deal with here is, therefore, the upper miocene only. It is much folded and faulted, forming stray folds and many faults at both extremities of the bed, and rolling in broad undulations in the centre of the plateau. Now, if we examine the much up-tilted beds near Futteh Jung, Nusrulla, or else close to the Salt Range near Kalabagh, we find them composed of a grey or greenish calcareous sandstone, of conglomerate and of sandy indurated clays containing nodules of kunkur. These beds look like inclined and parallel walls sticking out of the alluvium, and separated one from the other by open spaces or intervals; and one may at first sight fancy that the several strata have been wrenched apart at the time they were upheaved. But if we examine the beds where they are nearly horizontal, as in the neighbourhood of the Soane river near Kothair or Jubbie, we find that they consist of a hardly cohesive sand, very white and composed of minute grains of albite and quartz, with black grains of augite and spangles of mica. I have been in the habit, in taking notes, to call this sand, Pepper and Salt sand, and I shall here make use of this term, as it is a convenient one. Interstratified with this sand we find the beds of grey or greenish sandstone, of conglomerate and of sandy clay noted at Futteh Jung; and it becomes evident that at the places where we first observed the beds, and where they are much tilted up,

the pepper and salt sand has been washed out from between the harder beds, whilst in the horizontal strata, the sand has been protected by one of the strata of harder rock which acted as a roof over the sand underneath.

Now this pepper and salt sand is the one washed for gold. The washings are done during and after the rains, as the swollen waters of the torrents bring down to the beds of the rivers a large quantity of fresh sand. It is washed in the usual manner, and gives a residue of a black sand which is composed of shining grains of magnetic iron ore and grains of augite. A little more washing in a smaller vessel removes the augite and a great part of the iron; and the gold, which is rarely visible with the naked eye, is picked up by mercury.

If we examine the pepper and salt sand in situ, we shall very soon become convinced that it is nothing but the porphyry of the Himalaya ground down to powder, for we find in it numerous pieces of the porphyry not quite crushed to sand. I have found some of these pieces half an inch long and composed of a hard fragment of albite supporting specks of augite. Pieces of the large felspathic crystals I have seen also, and the smaller crystals of quartz are frequent and hardly altered and rubbed. The sandstone consists mostly of undecomposed albite and augite. It is not easy to describe in words the great similarity between the porphyry and the white sand, but their complete identity strikes one at once when we study the beds. Dr. Fleming made therefore a good guess when he wrote the following passage: "We have been quite unable to trace the source whence the gold has been derived, and are not aware that amongst the quartzites and quartzose mica slates (felstone is meant,) which are much developed in the Punjal Range, near the Baramoola Pass into Kashmir, and stretch west into the northern Hazara mountains, the metal has ever been detected in situ. From similar rocks there can be little doubt that the auriferous sands have been derived."*

And again he writes: "In the neighbourhood of the Salt Range the scales of gold are small and almost invisible, but we have heard from natives, that, in Hazara, grains of gold are sometimes found of a size such as to admit of their being picked out of the sand. If

* Report on Geological Structure of Salt Range; Selections, P. Govt. Vol. II. 1855, page 342.

this be true, we may infer that the auriferous source is somewhere to the north, and that by tracing the gold stream, so to speak, we might arrive at a point where the drifted materials become coarser, and where the gold, from its high specific gravity, has been deposited in larger quantity."*

That the miocene deposit of the Sub-Himalaya has been derived from the mountains situated N. or N. E. of it, is evident from the boulders contained in the conglomerates of the formation, these boulders being mostly volcanic rocks, such as we have seen in the mountains near the Baramoola, and such as we shall see in other parts of Kashmir. We will see, by and bye, that these volcanic rocks extend to the west, along the northern boundary of the Peshawur valley, as far at least as Jelalabad, and to the east as far, at any rate, as 80° east long., and probably much farther, though it appears from Captain R. Strachey's memoir on the geology of part of the Himalaya mountains,† that the volcanic rocks in the eastern portion of the Himalaya are more intrusive than they are in the western extremity of the chain.

If it is indeed true that grains of gold of some size are picked out of the sand in Hazara, some valuable diggings might yet be found in the valleys situated between the spurs of the Kaj Nag range or its extension to the west. But I cannot help thinking that, with a population everywhere anxious to wash gold even in very poor washings, auriferous sands of any economical value would have been worked long since, especially as the sands formed by the decomposition of a porphyry, similar to that of the Kaj Nag chain, and situated on the eastern frontier of Kashmir are searched for garnets only.

The magnetic iron ore is tolerably abundant in the pepper and salt sand, and is at present wasted by the gold-washers of Kothair and Mukud: but it has not been always so. In traversing the great miocene plateau of Rawul Pindee, I noticed for many miles along the road, between Pindeh Geb and Jubbie, small pieces of black slag, often in some quantity and evidently very old, as many pieces were seen where ravines had cut the ground, buried a foot

* Ditto ditto, page 344.

† On the Geology of part of the Himalaya Mountains and Tibet, by Captain R. Strachey, Bengal Engineers, F. G. S. Proceedings of the Geological Society of London, 1851.

and half below the surface. Knowing nothing then of the magnetic iron sand, I could not conceive whence the slags came, but on seeing the large quantity of iron ore which is washed out of the sand by the gold-diggers, I was forced to conclude that a time had been when the iron powder was saved and smelted. It is not such a poor undertaking as it might appear to wash iron from sand, especially as the gold alone would pay the men 3 or 4 annas a day, and a very little arrangement would save the iron. It contains about 70 per cent. of metal of the very finest quality and the very best to make steel. It resembles Swedish iron, and it is the same as the Kangra iron which has been proved to be of excellent quality by experiments in England. It is very dear, selling at £14 a ton. It is probable that the smelting of this iron sand was discontinued from the want of fuel, which is now very scarce on the plateau. That fuel was once more abundant, is sufficiently proved by the amount of travertin seen in many places where no springs exist now-a-days; and these fossil springs, if I may call the travertin by that name, tell us of a time when a higher jungle on the plateau and forests on the hills arrested a good deal of moisture, and wrung from the humid monsoons a portion of the rains which are now poured on the Himalaya. It would be, I imagine, easy for the local government to find out whether the magnetic iron ore is still smelted in some localities in the district, or when the smelting was discontinued, and to resuscitate the trade, the iron ore being brought to Mukud from the neighbouring villages, and there smelted with charcoal brought down in boats from the Akora Kuttuck hills or from Hazara. Excellent limestone is abundant near the banks of the Indus ten or twelve miles above Mukud. It is also abundant in the conglomerate on which Mukud is built.

The smelting of this iron sand would not, of course, give profits or yield a quantity of metal worth mentioning in comparison to the results of European industry, but it might be a valuable enterprise for natives possessing some little capital, and might much ameliorate the miserable condition of the gold-washers.

12.—Returning now to Buniar and the Kag Naj range, I must insist on the very changeable appearance of the porphyry. We have seen that it consists of a granular mass, with large crystals of albite, small crystals of quartz, crystals of garnet, plates of mica and lamellæ

of augite, and that any of these crystalline minerals or all of them may disappear, leaving a rock entirely composed of a saccharoid paste of albite. At other times the quartz becomes very abundant, and thick bands of white quartzite traverse the mass. Again, the augite, which is sometimes wholly wanting and at others in very minute specks only, may increase and at last predominate and form dark rocks with a semi-metallic lustre, the augite being generally collected in masses of aggregate plates having the lustre of iodine. It very often happens that the minerals are arranged in bands or layers as in gneiss, and this apparent foliation also varies much, and often it does not exist at all, whilst in other instances it is extremely well marked, thus gradually forming a passage to the clinkstone, described in the beginning of this paper.

13.—I have not visited the high summits of the Kaj Nag: indeed, I have only seen a few spurs of this enormous centre of mountains; but, from the road between Nausherra and Ori, one can see on the other side of the river, towards the tops of the hills, immense masses of the white porphyry glaring in the sun through the underwood which covers these mountains; and Captain H. Godwin-Austen, G. T. S., who assisted in the survey of this district, informed me that the white porphyry of the Buddist ruin at Buniar forms the summits and all the central system of the Kaj Nag range. From a coloured sketch kindly made for me by this officer we are enabled to see that the porphyry forms the whole of the main chain of the Kaj Nag, a portion of the huge North-Western branch, and extends along the western or Mozufferabad branch towards Hazara. The rock passes gradually from the granitoid porphyry I have described to less and less crystallized rocks, until it becomes the pencillated white and blue felstone which we have seen at Baramoola, and finally the earthy, slate-like felstone of the Atala mount.*

The summit of the Sank or Sallar, on the left bank of the Jheelum, I have also painted as volcanic porphyry, from my observing that the valley of the Apaikey is strewed with blocks of porphyry to a

* Captain Austen described the felstone as a hard slate, but as he said that this slate was identical with the "hard slate of the lofty cliffs over the road near Nausherra," it is evident that what was taken for slate, was an earthy slate-like felstone. At the time Captain G. Austen observed these rocks, he had not yet begun to study geology.

considerable height, and disposed in such a manner that they cannot have been brought from any other locality but the summits above. When I visited the Apaikey valley, the summits on both sides were covered with a thick mantle of snow, but the very shape of the peak, a smoothly rounded boss, was suggestive of a hill composed of materials which wear quickly and round easily under the influence of atmospheric vicissitudes.

14.—We must now endeavour to ascertain the extent of country covered by volcanic rocks similar to those I have described, and I am again indebted to Captain H. G. Austen for the following information: "The so-called granite, or, as you say more properly, volcanic porphyry, of the Kaj Nag is quite unlike the granite of the Deosais or Ladak, which is pure granite or syenite. This Kaj Nag rock is seen again in the mountains bounding the south-east end of the valley (of Kashmir) and in Kistwar; and the whole length of the Chota Dhar range, bounding Badrawar to the south, is of it; I have seen it nowhere else. It is so strikingly peculiar that I should certainly have noticed it, had I come across it in other parts of Kashmir."

How far the porphyry of Kistwar and Badrawar extends to the east, I have no means of judging;* but we have seen that the Kaj Nag extends towards the west into the upper part of Hazara; and I have had described to me some "granite" seen a few miles north of Mauserah, near the entrance into the Kaghan valley, which appears to be a volcanic porphyry similar to that which we have seen at Buniar.† But it extends still further west: Dr. Costello informs me that a great deal of "*granite*" and quartz occurs in and near the Umbeyla pass, lately occupied by the troops under General Sir Neville

* The "granitic" belt between the Sutlej and the Kali rivers, long. 77° to 80° 15′, appears to be a continuation of the porphyry of Kaj Nag, Kistwar and Badrawar. In Sirmoor, Garhwal and Kumaon it forms the centres of mountainous systems such as Chor, Dudatoli, Binsar, &c. Capt. R. Strachey describes it as "often porphyritic and much subject to decay." It passes into "*mica-shist* showing a distinctly laminated structure," (felstone ?) and also into greenstone.

† Also "a place on the road (to Mansera) as it passes along the eastern edge of the Pukti valley gets its name of *Chitti wat* (white stone) from several large blocks and hillocks of white felspathic rock containing large crystals, the same as that of the blocks on the ridge of Buri a few miles to the S. W., and like them visible "from a great distance."—*Journal of the Agricultural and Horticultural Society of India, Vol. XIV. Part I.*

Chamberlain. The General himself, in one of his dispatches, describes some of the hills as "granite," putting a note of interrogation after the word, and thus showing that the granitoid rock he noticed was sufficiently peculiar in its appearance to make it doubtful whether it was really a granite. From specimens of the mountains near the Pass, kindly given to me by Dr. Costello, I have no doubt that the so-called granite is one of the varieties of porphyry described in paragraph 12. It passes into a felstone composed of very elongated and large spindles of opaque, dirty white, and somewhat granular felspar and bluish semi-translucent glassy felspar, and in the spare felspathic paste which cements the spindles together, a few irregular grains are seen of a mineral having a metallic golden lustre, and which is probably Diallage or Bronzite. The rock has a great resemblance to, and is indeed identical with, the most compact sort of felstone seen at Baramoola. Bands of quartzite, of which I have seen very beautiful specimens as clear as Wenham lake ice, are also extensively developed, as well as enormous masses of compact gypsum and tabular selenite.

Dr. Bellew, in his "Report on the Yusufzaies," describes a variety of volcanic rocks occurring in the ranges which separate British Yusufzaie from Chumla, Buneyr and Swat: "Feldspar grit" and "various combinations of mica and felspar," "porphyry in a variety of forms," "trap-rock in great variety," quartz, mica and clay-slate, hornblende-rock, felspar-rock and amygdaloid; "hard trap" (greenstone?) "loose, friable and crumbling" ditto. (ash?) He also describes granite and gneiss; but he adds that the gneiss is quarried for mill-stones, and, if these mill-stones, (which is very likely) are similar to the mill-stones of Jellalabad, they are a coarse gneissoid felstone, and not a gneiss. The granite again is a whitish rock, and we find it connected with and surrounded by, rocks undoubtedly volcanic. I have no hesitation therefore in regarding it as a granitoid porphyry, similar to that of the Kaj Nag. A great deal of slate and "*primitive limestone*" is also mentioned in these mountains.

Dr. Bellew concludes that these hills are "all of primitive and metamorphic rocks;" but the list of rocks he gives, proves conclusively that they are of volcanic origin.

These volcanic beds in Yusufzaie are capped, in some places, by beds of

limestone, and these again by sandstone. No fossils have yet been discovered in either the limestone or the sandstone, and the age of these strata must therefore remain unknown for the present. Near Jellalabad beds of gneissoid felstone appear. This rock is quarried to make hand-mills which are brought down by the Povindahs and sold in Peshawur and the Derajat. These hand-mills are made of a coarse trachyte which has begun to effect a partial separation of minerals, and these minerals are arranged in streaks of white, granular felspar, greyish-blue felspar, with here and there a grain of augite. It is, therefore, again one of the varieties of felstone seen at Baramoola, and probably the same gneissoid variety quarried in Yusufzaie.

15.—By reference to the map we observe that the Pir Punjal chain is the first great parallel of the Himalaya, between the long. 73° 30′ and 76° E. It is a great chain, forming a belt of high mountains between the miocene districts of Jummoo, Rajaori, Poonch and Ori and the Kashmir valley, and at both ends of this great chain an immense accumulation of porphyries and other volcanic rocks, rising to tremendous heights, and covering some thousand square miles of country, are placed like two bastions at the extremities of a centric wall. What rocks then compose the connecting chain, the Pir Punjal? The reader will easily conceive how vexed I am that I was prevented visiting this range, more especially as the information I obtained from travellers is most conflicting and unsatisfactory. Mr. L. Drew, who has traversed the chain three or four times, was especially struck with the enormous development of a great slate bar of unknown age. We shall see in the next chapter, how very thick and extensive courses of slate are interstratified with beds of trachyte, ash and agglomerate, in the mountains bounding the Kashmir valley to the North. These slates are completely devoid of fossils, but as I hope to be able to fix the age of the volcanic rocks with which they are interbedded and contemporaneous, we had better reserve the discussion of their age until after the examination of the fossiliferous strata of Kashmir.

But the slates form only a band or bar in the Pir Punjal chain, and not the whole of it. I believe, that the remainder of the rocks of this range are mostly volcanic ash, felstone and agglomerates. A friend of mine and a very trustworthy observer, in the following passage

from a letter to me, is describing, I think, volcanic rocks, especially agglomerates and ash full of lapilli and volcanic conglomerates. "It (the lacustrine deposit of the valley of Kashmir) rests unconformably on trapean rocks, quartzite, quartz conglomerate, very hard and forming a compact mass." And again, further to the S. W. on the road through the Pir Punjal Pass, he says: "The rocks are principally mica-slate, with *thick beds of a hard conglomerate having a very fine dark blue matrix; this, in some places, was a mass of water-worn pebbles; but in most of it these are scattered through the mass, and are often in that case angular and small.* Up to the Pir Punjal Pass the dip is N. with a high angle; having crossed the ridge N. E. this continues all the way to Barangulla, giving these altered sandstones, slates and conglomerates an enormous thickness."* The excellent observer who wrote the above remarks did not think, it appears, that the rocks were mostly volcanic in origin, but I cannot help imagining that his description applies, in great part, to stratified ejecta of volcanic eruptions, and the passage I have put in Italics is, I think, a very fair description of ash with lapilli. Again, I must also remark that the felstone of Baramoola has always been described by travellers, and by geologists also, as mica-slate, though it contains no mica and is nearly wholly made of felspar; what has been taken for mica, being minute spindles of glassy albite. It certainly has a slaty cleavage, and the most earthy varieties have a close resemblance to metamorphic slate, and it is probably this fact which has misled most people as to the nature of the rock. It is not therefore impossible that some of the "mica-slate," mentioned above, is in reality earthy felstone.

16. The position of the Pir Punjal chain is rather peculiar, abutting as it does at both ends against enormous centres of volcanic rocks, and being separated by a great fault (the valley of Kashmir) from mountains also composed of the same rocks. In the enormous accumulation of amygdaloidal ash, agglomerate and conglomerate which we shall see, by and bye, on the other side of the valley, there is abundant proof of the existence of open volcanoes in this part of the Himalaya, at the time the porphyry was in a fluid or viscid state. The extreme

* I do not give the name of the person who kindly gave me the information quoted, as I do not agree with him on the origin of these rocks, and believe that he missed appreciating their true value, though his description is accurate.

regularity and evenness of the stratification of these cinder beds renders it highly probable that the showers of ejecta fell in a shallow sea in which the volcanoes formed islands. It appears to me, that we cannot refuse to admit that the porphyry was the base of the volcanoes, and indeed the matter which failed to escape through the vent in the earth's crust, whilst the felstone or clinkstone and varieties of trachytic rocks into which the porphyry always passes, are lavas which have flowed under the pressure of the sea. If these views are admitted, we have a series of volcanoes beginning at the Kaj Nag, and forming an arc along the north-east boundary of the valley of Kashmir, down again to the mountains of Badrawar: of this arc of volcanoes the Pir Punjal chain is the chord. Can we wonder, huge though the chain is, at its being in a great measure formed by ejecta of volcanoes received in a sea gulf and there arranged in conformable layers? The slate, as we shall see in the next chapter, was formed during the intervals of volcanic activity, and it is not improbable that the continual shower of ashes and hot stones into a shallow bay kept the water at a temperature too high for the devolopment of animal or vegetable life.

Since writing the above paragraph, Capt. G. Austen has informed me that beds of unmistakably volcanic rocks, such as amgydaloid and coarse greenstone, are interbedded with the slate and other rocks of the Pir Punjal. This is precisely what occurs in the hills north of the valley of Kashmir, we may therefore regard the Pir Punjal as a mass of volcanic ejecta interbedded with slate which was deposited during the periods of volcanic tranquillity.

Chapter II.—*The Mountains North and North-East of Kashmir.*

17. By referring to the map, we observe that the Kashmir valley is an elongated trough with its longer axis directed S. E.—N. W. The Jhcelum has a similar general direction, as far as the Woolar Lake, and the smaller stream which drains the north-western end of the valley flows from the N. W. to the S. E. To the north-east of this axis, we notice long spurs of hills which descend to the water-

edge of the Woolar Lake, the Manus Bal and the Dál and to the lacustrine plains of Pampur, Avantipoor, Bij-Behara and Islamabad. These spurs are the extreme south-western ends of a labyrinth of mountains which forms a barrier, nearly forty miles across as the crow flies, between the flat plain of the Kashmir valley and the chain of mountains which separates Kashmir proper from Drass, Sooroo and Ladak. If we consider the Himalaya as a series of parallel chains and valleys, we should have the Pir Punjal chain as one of the parallels; traversing the valley of Kashmir and the labyrinth of mountains to the north-east of it, we meet another great parallel chain, which has unfortunately no general name. It has been called by Col. Cunningham the Western Himalaya, but the name is evidently objectionable, as we want the term "Western," to designate the whole of the Himalaya between the longitudes east 73° and 79°, or between the Indus and the Sutlej. It has also been called the Central chain of the Himalaya by several authors, but the great quantity of snow which covers its peaks is merely the result of its being so placed, that it collects and condenses nearly all the remaining moisture contained in the south-western winds, and sends these winds perfectly dry to the Kailas and Karakoram ranges. The beautiful series of snowy summits presented by this chain is therefore no claim to its being the central chain of the Himalaya. I am afraid no other rule, but that of the division of drainage, can be considered safe in estimating which of the many parallel chains of a same system of mountains is the central one; and if we conform to this rule, the Karakoram range is to be regarded as the central chain of the Himalaya. It is therefore preferable to name the chain under consideration by the name of one of its great peaks, and as the Kun Nun or Ser and Mer Peaks (23,407 feet) are well known and very conspicuous in the western portion of the Himalaya, I shall make use of the term "Ser and Mer chain" to designate the great parallel range which separates the basin of the River Jheelum from that of the Indus.

Between the Pir Punjal and the Ser and Mer chains, we have not only the valley of Kashmir, but a number of independent and, as it were, isolated centres of mountains which, as I have said before, form a complicated labyrinth of hills and valleys to the north and north-

east of the Jheelum. If we travel, on the map, from the N. W. to the S. E. of the valley of Kashmir, following the banks of the Jheelum, we shall notice a series of mountains of moderate height, encroaching into the valley, and separated one from the other by broad lateral valleys more or less filled with lacustrine deposits. The first mountain we meet is on the eastern side of the Woolar lake, and is called the Safapoor (10,309). Its foot is bathed by a small but exquisitely picturesque lake, (Pl. 6) the Manus Bal. The next is close to Srinagar and is the Zebanwan (8813). Ten miles to the south-east, the Wastarwan, near Avantipoor, is the next summit; then, after crossing the valley of Trahal, we meet the hill of Kamlawan (8601), over the village of Murhama, and the Sheri Bal close to the Kamlawan. Crossing the broad valley of the Lidar River, we find the Hapatikri, a mountain which sends a spur to the S. W. to form the small hill of Islamabad at the foot of which the town of that name is built. Crossing the valley of the Arpat river, we meet with the Dhar (8146) and the Nawkan (9207). We have therefore, from the eastern shore of the Woolar lake to the extreme south-east of the Kashmir valley, a catenated chain of mountains composed of isolated summits, whilst their relations are covered by the diluvial and lacustrine deposits which fill the Kashmir valley, and the lateral valleys which open into it. This chain is therefore presented to us as a series of summits and not as a regular chain.* Its direction is that of the general parallelism of the Himalaya, viz. from N. W. to S. E. Ten miles, as the crow flies, to the northeast of this chain there is another similar one, that is to say a series of summits, apparently somewhat detached one from the other, but being in a line with the parallelism of the Himalaya. These mountains are from the S. E. to the N. W.—the Liwapatoor, the Wokalbul (14,310) the Girdwali (14,060), Batgool (14,423), Boorwaz (13,087), Handil (13,273) Saij Aha (11,334). West of the Saij Aha, this catenated

* I need hardly say that the catenated appearance of the chains described in the text is in great part due to erosion, and that this great erosion is only what was to be expected, if we remember that the whole rain-fall of the southern slope of the Ser and Mer chain has to find its way to the valley of Kashmir across these catenated chains, and that the Ser and Mer chains receive a tremendous snow-fall. I use the word "catenated," in the same sense as it is used in Anatomy, to designate the arrangement of the lymphatic glands of the neck, viz. like the beads of a necklace or rosary.

chain becomes blended with the first one I have indicated. Ten miles again to the north-east of the series of peaks just enumerated, is another chain of detached peaks or centres of mountains, arranged along a line parallel to the two others and to the general direction of the Himalaya. From the S. E. to the N. W. we have the following summits or centres of mountains: the Rajdain (15,389), the Gwasbrari (17,839) the Harbagwan (16,055), the Basmai (15,652), the Kotwul (14,271), the Haramook (16,903) and the numerous peaks which, with their complicated spurs, separate the valley of Kashmir from Gurais and Tillail.

Between all these catenated chains, connecting spurs or branches are to be seen spreading in all directions, and it is extremely difficult to give the direction of the resulting masses of mountains. But the geology of these mountains will help us a good deal to understand their topographical grouping. As we see these mountains on the map, we should be disposed to consider them as long spurs of the Mer and Ser chain descending towards the S. W.; but we shall see that all, or at least most of these summits, are composed in their centre of rocks which have once been in a fluid or viscid condition, that is of porphyry, greenstone, basalt and amygdaloid; that these melted rocks are covered by enormously thick layers of ash, agglomerate and slate interbedded, and that on the top of these beds of ejecta fossiliferous strata rest quite conformably. It becomes therefore evident, that the summits represent separate and isolated centres of volcanic action, no doubt much displaced by the last upheaval of the Himalaya, but yet preserving their relations to the beds of ejecta which were collected around their feet and on their slopes. We have therefore a linear arrangement of volcanoes, or at any rate of volcanic fused matter, (for some of the collections of melted minerals may not have reached the surface and never had a vent), this linear arrangement forming three parallel lines, and these lines being parallel to the general N. W.—S. E. direction of the Himalaya. I believe that similar lines of volcanoes or collections of volcanic matter are to be found between several of the great parallel chains of the Himalaya, but whether they are thus general or not, the ones in Kashmir are sufficient to prove that during the Palæozoic epoch, the volcanoes of the Himalaya had an arrangement more or less linear, and that the

great lines of fracture on which these volcanoes were situated, had the same direction as that of the Himalaya of our time.

18. Beginning with the southernmost line of summits, I will now describe in some detail the hills which compose it. I shall begin with that nearest to Srinagar, viz. the Zebanwan.

The Zebanwan is a mountain of 8813 feet at its highest point, with a general direction from E. to W. (Map B). Its eastern portion is nearly due E.—W., and is 2¼ miles in length. It then turns to the S. W., at the same time throwing out long spurs to the N. W. to embrace the eastern shore of the Dal. The Zebanwan keeps its N. E.—S. W. direction for 3¼ miles, when it bifurcates into two branches, a southern one, small and short, and a W. N. W. one, 2½ miles long. It is at the end of this W. N. W. branch that the Tukt-i-Suliman rises, a very conspicuous little hill, seen from nearly every part of the valley. Still further to the W. N. W., 2½ miles from the Tukt, the hillock of Hurri Parbut rises out of the lacustrine alluvial. It is evident that the Tukt-i-Suliman and the Hurri Parbut are only continuations of the W. N. W. spur of the Zebanwan, and appear as detached hillocks on account of the thickness of the lacustrine deposit. (Sect. A).

The following detailed section of Hurri Parbut, the Tukt-i-Suliman and the W. N. W. spur of the Zebanwan is at a right angle to the axis of these hills. It will give, I hope, a good idea of rocks which we shall meet again and again, and which I will, therefore, endeavour to describe now with some precision, as they are nowhere better seen or more conveniently studied.

Section of Hurri Parbut, Tukt-i-Suliman and W. N. W. spur of the Zebanwan. (Sections A, B, &c.).

Direction of chain: S. 65° E.—N. 65° W. General strike of beds S. E.—N. W. General dip of beds, north-easterly. The Section follows the direction of the range and consequently cuts the dip at an angle of about 65° instead of 90°. (See Sect: A). (Section II. of General Map). See also Map B.

Hurri Parbut. This hill is a succession of hard layers of trachy-dolerite and soft layers of other rocks. The trachy-dolerite is rough, compact, very hard and dark. I have never seen it scoriaceous. It is sparingly amygdaloidal, containing sometimes a few large geodes filled with white quartz. These beds are nearly vertical, with a dip east-north-easterly, forming with the horizon an angle seldom under 75°. The most westerly beds are nearly vertical, whilst the most easterly layers are more sloping. There are seven or

eight thick beds of this trachy-dolerite separated one from the other by the following rocks: (*a*) A slaty basalt, hard when fresh, but very soon falling into foliated debris. It reminds one somewhat of the earthy variety of the felstone of Baramoola. It is grey in colour. (*b*) an ash of a dirty-looking felspathic paste, full of rounded or oval nodules of dull augite or hornblende. These nodules are probably amygdaloidal in origin, being due to a bubbling of a hot paste of ash and water. It desintegrates very quickly into a yellow earth or a grey gritty soil on which grass grows well, soon concealing the rock below.

These beds of slaty basalt and ash are well stratified, and fill up all the spaces left between the layers of trachy-dolerite; this last rock forms prominent ridges or saddles on which the several works of the fort are built.

A marshy alluvial plain intervenes between the Hurri Parbut and the Tukt-i-Suliman.

Tukt-i-Suliman. The western extremity of this hill (as it appears above the lacustrine deposit) is a little knoll which has received the name of Rustun Ghurree.

1. Rustun Gurree: Compact greenstone either greenish or bluish; hard; fracture conchoidal. Either no amygdala or a few large ones, about the size of a pigeon's egg, often irregularly shaped, composed of white opaque quartz arranged in concentric layers and never crystallized.* Strike S. E.—N. W.; Dip N. E. = 50°. This is a hard rock and forms a prominent boss of a barren character. It is quarried for building purposes, but is too hard to be dressed, and as it breaks in angular pieces, it is altogether a very unsatisfactory building material. This bed has a thickness of about .... 60 ft.

2. A dirty yellowish-grey felspathic ash, full of geodes of dark augite. It decays fast, the nodules of augite, after partially decomposing and colouring the whole mass ochre-yellow, drop out of their niduses and leave a spongy mass of yellow earth somewhat resembling pumice, but not in its hardness. It is used as a good clay for pottery. It is much better developed on the northern than on the south-eastern side of the hill. In one section it is no more than .... 10 ft.

3. Resembling greenstone but much more amygdaloid. It is hardly seen on the southern aspect of the hill, where it is covered by vegetable earth and a cemetery; but it is well seen on the lake side near the water gate,... 20 ft.

4. Tukt-i-Suliman: A mass of amygdaloidal greenstone, sometimes compact, as at the base of the Rustun Gurree, but more generally showing dark specks of augite or hornblende in the mass. The amygdala of white quartz invade it, either as large and scarce geodes disposed here and there

* These amygdala of white quartz occasionally fall out of their matrices and are to be seen in numbers, half-buried in the soft silty mud of the lake near the village of Drogchand. Should this mud one day dry up into a rock, a false amygdaloid will be produced, all the more difficult to distinguish from fused amygdaloid, as the mud of the lake is entirely formed of the debris of volcanic rocks.

irregularly in the rock, or as smaller geodes mixed among long cylindrical and twisted branches of quartz running through the mass. (See figs. 1, 1*a*. plat. X.) I must confess, I had some difficulty in understanding these branches; they look precisely like the arms of a canal or like small rhizomes, and they sometimes have the form of worm-burrows; they begin with thick branches or trunks about the size of the finger and throw out smaller twigs; they are often 6 or 8 inches long, and are cut obliquely by both stratification and cleavage. I have come to the conclusion, after examining a great many of these cylinders, that they are gas-vents, similar to the amygdala in origin, the imprisoned gas, in its efforts to reach the surface, having had sufficient strength to force a long passage though the viscid paste.* Dip 55° to 60° .... about 600 ft.

5. Amygdaloidal greenstone, graduating to trachyte; with innumerable small geodes, rounded and pressed together. The greenstone becomes rough and gritty and passes into a trachyte, it is much less amygdaloidal; and on the other hand, where the rock is excessively amygdaloidal, the paste is a dark brownish black rock, which is cleaved into well defined slabs, and breaks easily into prismatic fragments. This bed forms a depression between harder layers. The stratification is easily seen by the several courses of the rock superposed one on the other; but of course it is not seen in the thickness of each course. .... about 200 ft.

6. Pale bluish greenstone, hard, compact, with conchoidal fracture; it is closely spotted with irregular dots of hornblende. At the base of each compact layer, there is a margin 1 or 1½ foot thick and very amygdaloidal, the geodes being filled with quartz. It is a very hard stratum ... about 150 ft.

7. Closely set amygdaloid. The paste is a greenish felspar, sometimes very compact and then dark, and cleaved into slabs half an inch thick; sometimes light in shade and with the amygdala rather irregular and nearly touching one another. In many specimens, the felspathic paste shows a division of the felspar into a bluish or greenish mass and patches of white felspar; but there is no crystallization. Dip 70° nearly due E. The felspathic paste decays pretty quickly and thus this bed forms a depression on the hill side. .... 50 ft.

8. This is the stratum on which the celebrated Buddhist ruin is built; it is the highest summit of the Tukt-i-Suliman (6263 ft.) It is composed of very hard, dark greenstone, with amygdala of white quartz, occurring sparingly. Beds of lighter coloured greenstone, with specks and nodules of augite are interstratified. A great many well defined long cylinders of quartz, either white or black or smoky, such as I have described as gas vents, are seen here. This stratum is a hard saddle or ridge; nearly vertical, and dipping easterly. .... 60 ft.

* I have since read that Dr. MacCulloch observed in Little Cambay, one of the Western Islands of Scotland, amygdaloid containing elongated cavities similar, I believe, to those which are here described.

So far, the rocks have been purely igneous. We now meet an alternate succession of igneous rocks produced by the decomposition and arrangement under water of volcanic minerals. Ash, agglomerate and other strata of volcanic ejecta become also much more abundant.

9. A dark blue slate, in places clayey, in others calcareous, and effervescing slowly and feebly with acids. It decays soon and forms a depression. It contains no trace of organisms.... .... 15 ft.

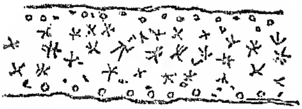
10. A lumpy brown rock composed of a coarse felspathic paste which weathers chocolate-brown and contains a great number of lapilli, mostly black and basaltic-looking. It shows thin, lenticular beds of pale grey felspathic ash containing innumerable geodes, filled, some with quartz, some with dark augite (?) This stratum is not very hard, and rounds by weathering, so that it forms a smooth round boss and not a sharp saddle. It is about ... 30 ft.

11. This bed is interesting and presents a very peculiar appearance.

The rock is a pale grey trachyte in which crystals of dull white albite have imperfectly formed and arranged themselves in tufts of imperfect crystals forming more or less a star or section, (see fig. plate X.) When the rock is polished, (such as is seen in the pavement of Srinagar where it is polished by people walking over it*) the starry disposition of the crystals is evident enough, though in the fresh broken specimen it is rather confused. The rock is a passage between a trachyte and a felspathic porphyry. I have never seen or read a description of this variety of volcanic rock, and I therefore propose to call it "Soolimanite." On the north-western flank of the hill, this bed of Soolimanite is better seen than on the other side, and there presents some layers which show well the nature of the rock. Some of these layers, rather darker than those we have seen on the other side of the hill, contain the starry crystals well developed in the centre of the beds only, whilst above and below, that is near the lowest and uppermost parts of the beds, the

* The stone is not abundant, and very few pieces of it are seen in the pavement of Srinagar. I have seen two however, one in the vegetable market near the great Musjid, and the other between the first bridge and the gate of the Shere Ganie on the left bank of the Jheelum.

Fig. 4.



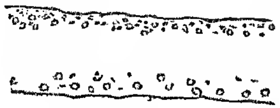


Fig. 5.

crystals disappear and are replaced by amygdala filled with quartz (fig. 4.) Other beds again of compact trachyte show neither starry crystals nor amygdala in their centres, but have their deepest layers invaded by large amygdala, and their uppermost portion full of small geodes, having besides a scoriaceous aspect (fig. 5).

In the middle of this bed of Soolimanite, some of the cylindrical tubes of quartz described before as gas-vents are well developed, branching in all directions through the rock.—Dip E. 70° .... about 30 feet.

12. Slate of various colours, laminated and very false-bedded, often squeezed and twisted. It has been folded, the lower part being nearly vertical with a dip westerly, whilst the upper part dips east 65°. The centre of the fold is much contorted and gathered in zig-zags, and in these contorted parts a great many gas-vents (branching cylinders of quartz) are well seen; some as large as the finger, others of the usual size, viz. a crow's quill. .... 200 ft.

13. A band of Soolimanite like 11. The slate of No. 12, has evidently been metamorphosed by the action of heat emitted by the band of Soolimanite which covers it. There must have been a considerable period of inaction between the two out-pours of Soolimanite to enable the slate to become collected, and it is evident that the slate was yet in the state of a silty mud at the time of the second eruption and was set bubbling by the heat of the Soolimanite.

I may here remark that I am satisfied that many of the layers of laterite, cellular slate and ash, which we shall see in this section, are nothing but true sedimentary deposits metamorphosed and rendered amygdaloidal by the bubbling or boiling of the waters which covered them. I had thought at one time, to try and distinguish the beds of ash and volcanic mud which were probably formed as I have just explained; but I found the work too uncertain and requiring too much time to be worth prosecuting. But no doubt can be entertained that, besides the slate and laterite, many of the beds of the mountains of Kashmir which appear to be volcanic ash or dust, are in reality metamorphosed sedimentary layers.

The Soolimanite has a thickness of .... 15 ft.

14. The band of Soolimanite gradually passes into a felspathic ash, often friable, but often also hard and compact and full of oval nodules of dark augite, varying in magnitude from the size of a pea to that of a pin's head. Occasionally the ash passes, along the strike, into a hard compact quartzite. The whole bed appears irregular and lenticular, and has been probably formed by ejecta falling into shallow pools of water .... 15 ft.

15. A calcareous rock which is not seen on the hill side, but gives out, on the brow of the hill, a good deal of nodular muddy carbonate of lime (kunkur). Here and there a brown ferruginous rotten ash (or metamorphosed calcareous shale?) crops through the grass on the top of the hill. It effervesces feebly with acid, and is probably the rock which gives out the kunkur. This layer, which is probably squeezed out of its place near the foot of the hill by the gradual curving of the strike of the harder rocks, is, at the top of the mount, at least .... 20 ft.

16. A thin band of amygdaloidal greenstone .... 12 ft.

17. Slate, grey. On the western side of the bed it dips W. N. W. 65°. In the centre it is much folded; on the eastern side it dips E. S. E. 75°. This angle, however, diminishing quickly to 65° .... 20 ft.

18. Greenstone alternately coarse and fine .... 20 ft.

19. Slaty basalt, dark bluish black, fracture conchoidal. It dips E. a few degrees S. 70° .... 30 ft.

20. A crumbling, brown, lumpy metamorphic mud, slightly amygdaloidal. It decays rapidly into a dirty yellow coarse gravel. It is interbedded with bands of agglomerate, the lapilli being mostly basalt .... 50 ft.

21. Sandstone, hard, rough, quartzose and micaceous; apparently much altered by heat. No organisms .... 3 ft.

22. Coarse quartzose grit, very hard and rough. It appears to be composed up of angular grains of quartz, variously coloured, cemented together by a siliceous paste. It may be a siliceous deposit in which crystallization of the purer quartz has begun to take place .... 15 ft.

23. Sandstone like 21. Dip. S. E. .... 10 ft.

24. Blue compact slate, becoming gradually first coarser and more like a shale, and then more silty or like yellow and grey clay-slate. The stratification is best seen by the coloured markings which indicate it to be only 25° and E. The bed has probably been squeezed out of its place .... 150 ft.

25. Coarse yellow sandstone with a calcareous cement. Cleavage well marked. No organisms .... 20 ft.

26. Slate, thin bedded and falling into angular fragments. It is mostly deep blue with bands or ribbands of yellow and grey. The dip is more regular than that of the slates seen before. It is nearly due E. with an angle of 40° .... 200 ft.

27. Slate, fissile. It differs from the preceding by decaying much more quickly by exposure, the whole bed being covered by small débris. It dips W. on its western side, and E. on the eastern, whilst the centre of the fold is zigzagged .... 30 ft.

28. Slate, compact and dark blue .... 8 ft.

29. Slaty shale, grey and dark, dipping W. a few degrees N. at an angle of 55°. It is continued (underneath) by coarser shales which form an anticlinal (not easily seen on account of débris and of the decayed state of the shale). On the other side of the anticlinal the dip is nearly due E. 60°. The extent of outcrops of this layer (not its thickness) is about...... 5 to 600 ft.

30. Metamorphosed slate, fissile and greyish blue; much jointed; the joints are yawning, sometimes a foot apart; they strike W. E. vertically. The stratification dips E. S. E. with an angle of 50°, but that is much falsified by the stratum inwrapping the end of the spur. This bed presents in its middle, thin layers as follows:

a. Soft, yellow quartzose sandstone, nearly friable, 8 inches. *b.* Dirty quartzite, 8 inches. *bb.* Do. with veins of pure white opaque quartz, 1 foot. *c.* A hard, brown, baked quartzose with spreading veins of quartz, 6 inches. Total 3 feet. The whole outcrop of the bed (not its thickness) is about 130 ft.

Here ends the Tukt-i-Suliman, and between this hill and the foot of the W. N. W. spur of the Zebanwan passes the road from Srinagar to the Nishat Bagh. (Sect. A).

The W. N. W. Spur of the Zebanwan. Ascending this spur in the continuation of the section, we have the following beds:—

1. Slate more or less laminated, with large yawning joints striking W—E. The stratification is well shown by the colouring of the slate; it dips W. 45°; inwrapping the end of the spur.

It may be here remarked, that the beds of slate, ash and fossiliferous rocks nearly always present this inwrapping arrangement at the end of spurs and when they cross a spur; it appears that these beds had plasticity enough to bend all round when upheaved by inferior rocks. A fine example of this inwrapping arrangement is seen in the limestone which terminates the spur of the Zebanwan over the village of Zeeawan: the limestone, in endeavouring to arrange itself around the band of volcanic rock which upheaved it, has split into slices from 5 to 15 feet thick, diverging like an open fan. (Sect. C).

To come back to our section, the slate has a tendency to break into prismatic pieces, and the joint-surfaces are coated with a yellowish or

dirty white quartz. This bed is evidently a continuation of the last bed of the Tukt-i-Suliman (30 of section A), and the road passes over a synclinal, which would be very evident, were it not for the inwrapping arrangement of the slate at both extremities of the bed. As we go up the hill, we observe that the bed forms a small eminence of its own, being separated by a fault from the western beds which have a general south-easterly dip. It extends for about a thousand yards along the southern aspect of the hill, wheeling round and, as it were, lining the foot of the spur, its dip becoming gradually more southerly until it is S. W.

2. Following our section, we find, after the fault, the same alternate disposition of felspathic ash with nodules of augite, of dark slate more or less laminated, baked and metamorphosed, and of volcanic agglomerate full of dark coloured lapilli. It would be tedious and unprofitable to give a minute description of each bed, especially as the enumeration would be a long one, each bed being seldom more than 10 feet in thickness. No greenstone was seen for more than half a mile; the ashes are always tolerably compact when not in a decomposed state, and always invaded by innumerable nodules of augite. They are always well stratified, and it appears therefore evident that the whole of the ejecta fell into water, by which they were arranged in well defined strata. The amygdaloidal condition of nearly all the rocks, whether ash or slate, seems to indicate that the water was raised to a high temperature during the volcanic eruptions; and the want of animal remains in the slate beds and amongst the agglomerates is in accordance with this hypothesis.

It goes on, as I said before, for above half a mile, alternating ash and slate, with occasionally a dirty-brownish bed of rotten and calcareous ash decomposing very fast and throwing out, on its surface and also between its joints, a large quantity of kunkur. The strike of the beds turns gradually to true N. S. and the dip is E., the angle with the horizon being between 60° and 70°. Beds of laterite now begin to appear, of a yellowish grey colour and resembling indurated clay. They are a little harder than slate, sparingly amygdaloidal, and the geodes are very small and filled with quartz. They break into small cuboid fragments. These laterites are interstratified with beds of dark slate, and lying over them we get the following strata :—

x. A band of greenish-grey trachyte with small rounded geodes of chalk-white albite. It weathers somewhat reddish on its outside and wears in rounded masses. It reminds one very much of some of the felstone of Baramoola. Strike N. 15° W.—S. 15° E. Dip Easterly 40°. But this stratum varies very much along its strike, becoming in places a ferruginous, rotten, augitic amygdaloid; in others a sandstone made of big rounded grains of quartz, of hornblende and of other volcanic minerals, with a calcareous cement which effervesces powerfully with acids. This sandstone forms slabs 1 to 1½ inch thick, and superposed one over the other like bricks in a wall. Again a little further on, it is a fine, very compact, smooth laterite, passing gradually into a more sandy variety containing very minute spangles of white mica hardly visible in the day time, but which shine well by candle light, and also a few small rounded nodules of a pale green semi-lucent mineral. The variations of this bed along the strike seem to indicate a very shallow shelving shore or a pool of water, the bottom of which had been frequently disturbed by the appearance of lavas or other heated matter. The bed is about 15 feet thick at the outcrop.

xi. Then the slate, blue and compact, comes again, with occasional thin beds of sandstone or dark-stone: a coarse grained highly ferruginous amygdaloid, a sort of poperino, forms a bed 15 feet thick, and on the top of this, here and there, are patches of grey laterite. The slate and the sandstone alternate repeatedly in beds of more than five feet each, and this goes on for a thickness of about 160 feet.

xii. A ridge of coarse, brown, slightly micaceous sandstone, in superposed slabs like a built wall, now makes its appearance. It strikes S. W.—N. E. and dips easterly 45°. This strike S. W.—N. E., meeting the strike of the preceding layers *x* and *xi* which is N. 15° W.—S. 15° E., leaves an open angle or yawning on the northern flank of the hill, and this is filled up by laminated slate, much broken and of various colours, a good deal of it being yellow. It is the yielding of this soft slate which has allowed the hard and unyielding sandstone to take a direction to the S. W. instead of to the S.

The thickness of this sandstone ridge is about 45 feet, and that of the slate, which fills up the gap or yawning on the flank of the hill, about 40 feet.

xiii. Slate, hard but much cleaved; about 80 feet.

xiv. A ridge of very compact and massive baked clay, having a conchoidal fracture and large distant joints. It is yellowish grey in colour, with bands of lighter yellow: one would take it for a light-coloured basalt, if it were not for its trifling hardness, which is about that of slate. It appears to be a clay made up of silty mud, derived from basaltic and other volcanic rocks and baked after formation. Perhaps it would be best named "Massive Laterite." The joints and the surface are covered with a rich brown iridescent oxide of iron or a black crust of the same material. This rock is nearly vertical, and is near a fault of considerable extent which cuts the hill right across;

and this proximity to a large fault might perhaps account for the metamorphosed appearance of the clay.

FAULT.

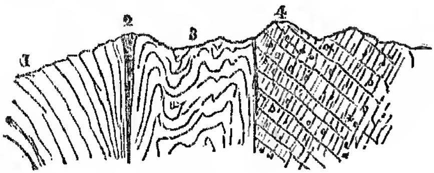


Fig. 6.

1. Slate. 2. Massive Laterite or Baked Clay.
3. Slate, Ash and Laterite in the fault.
4. Amygdaloidal Greenstone.

The fault is about 500 feet wide, and is filled with zig-zagged slate, ash and laterite. A very great deal of kunkur is found all over the ground. This fault goes right across the hill, from near the ruin of Pari Mahal to the small spur over the village of Pandrettan.

East of the fault, the rocks are very different; they are rocks similar to those we saw at the foot of the Tukt-i-Suliman; viz. greenstone and amygdaloid, and there has been therefore a downthrow on the west of the fault. The strike is very different on both sides of the fault. We have seen that on the west side it is S. W.—N. E. with an eastern dip; the greenstone and amygdaloid strike S. E.—N. W., dipping to the N. E.

There is no occasion to describe these greenstones and amygdaloids again, as I have done so before at the foot of the Tukt-i-Suliman. But we must notice here a very great quantity of what I have called gas-vents; the amygdaloidal greenstone is in some places completely perforated by these vents which are sometimes filled with quartz, sometimes with augite, and sometimes left empty. (See figs. 1. 1a, Pl. X.)

20. Crossing the broad ravine above the village of Pandrettan, a ravine in which once flourished a Buddhist city of which the ruined walls are still to be traced, we notice a spur composed of dark and brittle basalt, much jointed but not columnar. It is interstratified with a volcanic ash, similar to that seen in the Rustun Gurree. The end of the spur presents a fine example of beds of ash and laterite inwrapping or infolding subjacent beds: the spur is narrow and the layers of ash and laterite are bent down on each side of it, just as a layer of paste laid across a ruler would by its weight bend on each side of the ruler. The dip of the beds is N. E., and consequently the strike is obliquely across the spur which has a W. south-western direction, and when we look up the hill, facing to the N. E., we can then see the beds of ash and laterite cropping out one above the other, like steps,

and forming arches along the strike. This curvature of course falsifies the dip on both flanks of the hill, the dip becoming northern on the south eastern flank of the spur, and south east on the other flank.

The lowest portion of the spur forms a little mound on which may be seen the remains of a gigantic Buddhist figure. The figure is that of a woman, but it is now prostrate and headless. It is a huge block of limestone. There are many other Buddhist remains at Pandrettan, all built of that rock: amongst others, a small temple in a tank is well worthy of a visit.

From Pandrettan to Panchhooka, we have a succession of thick beds of dark basalt, cleaved and jointed but never columnar, and greenstone and amygdaloid, with a few beds of compact ash containing oval nodules of augite. The basalt is the only rock which has not been described before. It is best seen in a little spur which descends to the Jheelum, hardly half a mile east of the Buddhist figure on the little knoll. It has sometimes a very black and conchoïdal fracture, and at other times a pale pitch and bluish colour. It breaks into prismatic blocks which are quarried at the place where the spur hangs over the river. It does not appear to be amygdaloidal, but the greenstone into which it passes is sparingly so, the geodes being large and filled with quartz. It is difficult to ascertain the stratification or superposition, owing to the well marked cleavages and joints, but by observing the beds of compact ash occasionally met with, it is found to be easterly at a very high angle with the horizon. All the way from the stone quarry, at Alwajin, to that portion of the village of Panchhooka, designated on the map as "Large Cheenar Trees," there is a succession of these beds, but the angle of dip diminishes gradually as we travel eastwards and is only 45° at Panchhooka. There we find the following beds:—

A. slaty basalt, dark and heavy, dipping to the E. a few degrees S. at an angle of 45° with the horizon. It has a cleavage dipping due W. with an angle of 45°, and vertical joints striking S. W.—N. E. It is succeeded by a coarse trap, a sort of trachyte showing a certain amount of crystallization, the rock having a granitoid or rather gneissoid appearance. The augite and the glassy felspar are the only minerals tolerably crystalline, the remainder being a paste which is sometimes nearly white, or yellow and rough; sometimes greenish-grey and conchoidal in fracture, or blue, indigo-blue and

French grey. There is much in these strata to remind one of the starry trachyte or Soolimanite of the Tukt-i-Suliman, but the starry arrangement of elongated crystals of albite is never perfectly seen.

A layer of amygdaloid covers in the trachyte.

From Pandrettan to Panchhooka, we have been examining the beds of the southern spur of the Zebanwan. The W. N. W. spur may be considered to end or rather to begin over Pandrettan, and from thence eastwards we cross the digitations of the southern spur. A glance at the horizontal section (Map B) will render any further explanation unnecessary.

Here ends our section through Hurri Parbut, the Tukt-i-Suliman and the W. N. W. portion of the Zebanwan.

21. We will now examine the south-south-eastern flank of the Zebanwan, following a section from near Panchhooka towards the E. N. E. (See Map B.) (Section III. of General Map or Map A.)

We meet first a long slender spur proceeding from the main range of the Zebanwan to the S. S. E., and as this spur is very interesting, I have called it the Zeeawan spur from the name of a village situated close to its extremity. (Sect. A, B and C.).

The Zeeawan spur is composed, high up the hill, of the same basalt, amygdaloid and greenstone which we have seen in the preceding spur, but towards its end it is made up of enormously thick beds of volcanic agglomerate. This agglomerate is composed of a cement having the shining appearance of a slag, but not in its vesicular arrangement. It contains lapilli of nearly all the rocks which we have seen before, viz. greenstone, basalt, amygdaloid, slate of various sorts, and pieces of both felspathic and augitic ash. These lapilli are quite angular and crammed together so close that in some places the cement can hardly be seen. This cement appears to have at first coated the fragments with a thin layer of a dark shining paste, and then glued them together with a coarser material; or it is very possible that this coating is a superficial melting of the lapilli, and that the cement is a lava. However this may be, this agglomerate forms the greater portion of the spur. A confused stratification is discernible, dipping to the E. S. E. at a higher angle, and cut at right angles by well marked joints; thus huge blocks are separated from the mass and

strew the ground at the foot of the spur. Towards its end, the spur bifurcates into two digitations, the most westerly being entirely made up of agglomerate, whilst the most easterly presents the following section :—

Section of the end of the Zeeawan spur above the village of Zeeawan. (See Sections B. and C.)

1. Volcanic agglomerate with a shining, dark, semi-vitreous cement. It is interstratified with bands of amygdaloid and thin layers of peperino.

2. Quartzite, white, opaque, stratified; it breaks into cuboid fragments, owing to numerous well-marked joints. It is sometimes yellowish, but usually quite white. It is a conspicuous layer and deserves to be remembered, as it always occurs between the volcanic rocks and the beds of limestone to be hereafter described.* .... 15 ft.

3. Compact basalt, of a dark colour and breaking in prismatic pieces. It is often scoriaceous on the surface of layers........................ 20 ft.

4. Compact amygdaloidal greenstone. .... 3 ft.

5. Greyish-blue basalt; heavy; much fissured. .... 5 ft.

6. Coarse yellow sand, with numerous water-worn pebbles of the basalt No. 5 imbedded in the sand. The pebbles are lenticular in shape, such as are seen on the shores of lakes and sluggish rivers, and unlike those rounded by torrents. .... 6 ft.

7. Sandstone, grey and bluish, but weathering to a fawn-colour. It contains a few water-worn pebbles similar to those seen in the preceding layer. 3 ft.

8. Slate, greyish-blue; fissured and foliated. .... 5 ft.

9. Sandstone of rolled grains of quartz. .... 3 ft.

10. Slate, as before. .... 3 ft.

11. Compact and dark rock, much jointed and breaking in flat square pieces. Either a baked clay or a laterite. It is all broken to pieces on the surface of the bed. .... 5 ft.

12. A conglomerate of water-worn pebbles of trap united by a calcareous cement. The pebbles are not lenticular, but rounded........................ 2 ft.

13. Dark shales containing débris of fossils not determinable. ... 10 ft.

14. Limestone; dark greyish-blue; coarsely crystalline; in places very impure, argillaceous and shaly. It is a mass of fossils. .... 5 ft.

* Having now reached the fossiliferous strata, I shall not, in charity to the reader, give the section of the spurs of the Tukt-i-Suliman and Zebanwan which face the little lake or *Dal*. But the map (see Map B) will enable any one wishing to know the geology of these spurs, to satisfy his curiosity. I have indeed to apologize for the minuteness of the section of the Tukt-i-Suliman, &c. But in a country new to the geologist, a section, I think, cannot be too minutely detailed.

15. Dark brown calcareo-ferruginous' shales, exfoliating in thin plates and undergoing quick decay. It weathers nearly black. Extremely rich in fossils. .... 10 ft.

16. Limestone. .... 10 ft.

17. Dark brown calcareo-ferruginous shale.. 15 ft.

18. Limestone. .... 10 ft.

19. Sandy shales, very dark nearly black; do not effervesce with acids; very rich in fossils. .... 10 ft.

20. Limestone; less coarse than preceding; very fossiliferous. . 15 ft.

21. Limestone; hard and arenaceous; separated by thin layers of shale which weather dark brown and appear in relief on the section of the bed.... . ... 5 ft.

Any further bed which may exist is concealed under Eboulis.

22. When I first met with this bed of limestone, I was particularly delighted, as I had seen no limestone in Kashmir, except the huge carved blocks of the Buddhist ruins near Srinagar and at Pandrettan. I was told that the fine bluish-grey limestone of these ruins was no longer to be found in the country, and that nobody could guess whence the stone had been obtained. Even some of the Surveyors of the Kashmir Series, G. T. S. corroborated this opinion, which appears to be the received one amongst the natives. I could see at a glance that here I had the very stone, and in examining the bed I came across the remains of an old quarry. I subsequently found some much larger Buddhist quarries of limestone, as we shall see by and bye.

Misled by Mr. Vigne and Dr. A. Fleming, who, as I have said, stated that they obtained nummulites from the Kashmir valley, I began to look diligently for these foraminifers. I found indeed a few rounded bodies which might be taken either for nummulites or rings of crinoid stems. I did not at first hit on a very good portion of the bed for fossils; those I found were extremely weathered, and I could only pay flying visits to Zeeawan. But I tried once more to discover nummulites, when lo! I came across a Productus! The following genera were found to be abundant: Productus, Athyris, Orthis, Strophomena or Leptæna, and Spirifers amongst the Brachiopods. Very few lamellibranchiates and gasteropods were seen, but an immense number of Bryozoa, especially two or three genera of *Fenestellides*—viz. *Acanthocladia* and *Fenestella* and

innumerable inviduals of what has been called *Vincularia multangularis* (Portlock), but which some say is not a *Vincularia* at all. Some of the fossils are familiar to every body: the *Productus semi-reticulatus* (Martin), *P. costatus* (Sow.), the *Athyris Roissyi* (L'Eveillé). Other fossils are interesting on account of their rarity, and first amongst these is the claw of a crustacean, the pincers of which are two and a half inches in length. Though the pincers are neither teethed internally nor flattened into organs of natation, we may, I think, refer the fossil provisionally to the genus *Eurypterus*, if it is not even a true *Limulus*. (See Pl. V. fig. 4.)

23. We have therefore, resting on the volcanic rocks, beds of carboniferous limestone. These beds are of great thickness, and they change their characters very considerably as we follow them upwards. I have divided them into three great divisions, and I have called these by the names of the localities where they were found to be well developed. The lowest bed, which we have just seen, I have called the Zeeawan bed, from the village of Zeeawan. The next above will be called the Weean bed, from the village of Weean near which it is well developed; and the uppermost division I have named the Kothair bed,* from the name of a small district at the foot of the mountains where this upper bed is well seen. I have preferred adopting these names to the plan of using the designations of Lower, Middle and Upper, as further observations may render it desirable to sub-divide any division into two or more sections, in which case the terms lower, middle and upper would become inconvenient. In the present state of our knowledge of the geology of Kashmir and the N. W. Punjab, we may nevertheless remember with advantage, that the Zeeawan is the lowest, the Weean the middle, and the Kothair the upper bed of the mountain limestone.

24. To come back to our section near Zeeawan: we must first notice the inwrapping disposition of the beds around the end of the spur. The general strike of the volcanic rocks is N. N. E.—S. S. W.

* So few fossils were found in the Kothair bed, that it is not possible to place it, with any certainty, in the carboniferous; the same reason prevents its being placed in the Permian or Triassic. The place of this bed as the uppermost carboniferous is therefore only temporary. See the remark after the list of fossils found in the Kothair bed, Chapter II., para. 50.

and the dip E. S. E. High up the spur, this dip forms a considerable angle with the horizon, but it diminishes gradually as we descend towards the plain; at the bed of quartzite it is about 45°, and at the limestone it is generally 40°. But these rocks, that is from the quartzite upwards, appear to have been upheaved by a narrow band of hard rock catching them in the centre and pressing them upwards in that central point, whilst the sides of the beds were unsupported. Instead of yielding softly and shaping themselves into a carapace-like coating, as slate and ash would have done, the limestone and the shales have separated into thick bands or slices, and these bands have spread themselves out like a fan. At the small end of the fan there has been a considerable crushing of the beds one against the other, and enormous blocks, indeed whole pieces, of the limestone courses have been squeezed out of place; whilst, at the circumference of the fan, the beds have been parted from one another, and in some places we can see the layers of limestone separated by open intervals two or three feet wide. (See horizontal section, Sec. C.)

25. I will now try to define the character of the Zeeawan bed of carboniferous limestone:—Its lithological characters are, that it is a rough, coarse and semicrystalline limestone of a dark bluish-grey colour, weathering a rich grey. If we break it, we find it made of innumerable irregular grains of a darker limestone united by a lighter cement more or less crystalline. It is full of debris of fossils; indeed I am not quite sure that the darker grains are not the debris of the organisms or excrements of animals. It is fœtid. Portions of it are arenaceous or rather shaly, and these, when exposed to the air, decompose partially, becoming soft and crumbling. The stone is soft to work and cuts with great ease, except where there are too many large fossils. It contains an immense number of minute crinoid-stems converted into spar: it breaks obliquely to the surface and gives flashes of light at certain angles. It is interstratified with courses of rich-brown calcareous shale, often of a bright rust-colour, and generally much decomposed and with bands of a black, not calcareous, sandy shale: it is also full of fossils, these being apparently converted into oxide of iron. Finally, it contains limited short lenticular layers of a much paler limestone, in thin-bedded and false-bedded patches having somewhat the appearance of a fine mortar or cement.

The characteristic fossils of the bed are the following :—

Productus Costatus (Sowerby).

„ *Semireticulatus* (Martin).

„ *Cora* (D'Orbigny).

„ *Humboldtii* (D'Orbigny).

„ { *Flemingii* (D'Orbigny).
{ *Longispinus* (Verneuil).

Athyris, Sp. ——— Pl. II. fig. 1 & 1*a*. *A. Subtilita* (Hall)?

„ *Roissyi?* (Verneuil) Pl. II. fig. 3 & 3*a*.

„ Sp. Nova (A. Buddista, Verchère) Pl. II. 2, 2*a* 2*b*.

Spirifer (Sp. Verchèrii (Verneuil) Pl. I. fig. 1, 1*a* & 1*b*.

Spiriferina octoplicata? ——— Sowerby, Pl. I. fig. 2, &c.

Orthis Crenistria, Phill. ———

Strophomena Analoga, Phill.? Pl. II. fig. 4.

Fenestella Sykesii (Koninck).

„ *Megastoma* (Koninck).

„ Sp. ——— Pl. V. fig. 1.

Vincularia Multangularis (Portl.)

Acanthocladia, Sp. ——— Pl. V. fig. 4.

We shall have therefore no difficulty in identifying this bed wherever we meet it, as the Bryozoa make a great show and immediately attract attention. The coarse granular limestone is unlike that of the other beds we shall see hereafter; the rich brown shales are also peculiar to the Zeeawan bed, and even the position close over the glaring white quartzite would assist us, if necessary.

Contributions to Indian Malacology, No. VII. List of species of Unio and Anodonta described as occurring in India, Ceylon and Burma.—*By* WILLIAM T. BLANFORD, *A. R. S. M., F. G. S.*

[Received 5th September, 1866.]

There are few genera in the whole range of natural history more puzzling than *Unio* and *Anodonta.* Every naturalist who has attended to them has been struck by the great variation of which the different species are susceptible, though it is to be regretted that this knowledge does not appear to have had much influence in restraining some naturalists from recording as distinct species isolated specimens which reached them from distant countries, and which only differed from other specimens in characters of very doubtful specific value.

Although the *Unionidæ* of the Indian waters are far behind those of some countries, and especially of America, in the amount of variation which they exhibit, amply sufficient is shewn to render them very difficult to classify. And as the question of variation is one of the most important, especially at the present day, in the whole range of zoological science, those animals which, in the wild state, exhibit the greatest amount of variation, are peculiarly worthy of study.

In endeavouring to classify the Indian shells, one great difficulty that I have found, has been the determination of described types. Descriptions of Indian *Unionidæ* are scattered through many works, not easily procurable in India. There are, probably, yet a few to which I have not had access, but as I have been able to compile a list, comprising, I believe, a very large majority of the published forms, I think that I shall be aiding any one who, in India, may be engaged in the same study, by printing the list, with references to the original descriptions and to figures, whenever such exist, and by adding such remarks as appear to be necessary.

I also hope to be able to publish figures of a considerable proportion of the species named; in some cases, copies of the original illustrations; in others, drawings of authentic specimens. I shall feel greatly indebted to any one who will aid me in this endeavour by furnishing me with typical forms, or with any specimens from distant parts of the country. In all such cases, a small series of the varieties and different ages is desirable.

The present list, therefore, is merely an instalment of what I hope may be an illustrated monograph of Indian *Unionidæ*.

It is not my intention at present to enter at all fully into the question of the limitation of specific forms. I would merely point out, that some of the described species are certainly within the ordinary limits of variation of others described as distinct. Thus out of one tank in Calcutta, I have taken specimens unquestionably belonging to *U. Corrianus*, Lea, others which were nearer to *U. lamellatus*, Lea, and young specimens representing *U. bilineatus*, Lea, whilst other forms again appeared to appertain to *U. anodontina*, Lam., (or, at least to the species figured as such in Küster's monograph) which by Lea is classed as a variety of *U. marginalis*, Lam. Yet all these forms were unquestionably identical, being united by numerous intermediate varieties, all living together in the same small pond.

Lea's figures in the Journal of the American Philosophical Society, and the Transactions of the Academy of Natural Sciences of Philadelphia, are so good and characteristic, that the difficulties which might otherwise exist in identifying forms discriminated by such minute and variable characters are obviated. Benson's species, of which only descriptions exist, are far more difficult to identify, and Gould's, which are but briefly described, still more so. Küster's monograph, in Martini and Chemnitz's Conchylien Cabinet, contains figures of but few Indian and Burmese Unios, and of those, several are incorrectly named.

For convenience sake, the species of *Unio* inhabiting India proper, Ceylon, Assam, and Burma will be separately enumerated. The species referred to *Anodonta* are so few that subdivision is unnecessary, especially as none occur in India or Ceylon. No typical form of the genus is known to exist in the Indian or Burmese area.

The following works are referred to in the ensuing pages by the abbreviations appended in each case.

Müll.—O. F. Müller, Historia Vermium, 1774 (not procurable in Calcutta).

Chemn. Conch. Cab.—Martini and Chemnitz systematisches Conchylien Cabinet. About 1780? (not procurable in Calcutta).

Gmel.—Caroli a Linne Systemata naturæ. Tom. I, Pars. VI, 1789.

Lam.—Lamarck, Histoire des Animaux sans vertebres, Vol. VI. 1819.

Gleanings in Science, Vol. I., Calcutta, 1829.

Küster, Mart. and Chem.—Systematisches Conchylien Cabinet von Martini und Chemnitz, 2nd edition, by Dr. H. C. Küster and others. Vol. IX. Part 2, commencing in 1843 : unfinished.

Ann. and Mag. Nat. Hist.—The Annals and Magazine of Natural History, London, 3rd series, Vol. X. 1862.

Trans. Am. Phil. Soc.—Transactions of the American Philosophical Society held at Philadelphia, new series, Vol. IV. 1834; Vol. V. 1837; Vol. VI. 1839; Vol. VIII. 1843.

Jour. Acad. Nat. Sci. Phil.—Journal of the Academy of Natural Sciences of Philadelphia, Vol. IV. 1858-60; Vol. V. 1862-63.

J. A. S. B.—Journal of the Asiatic Society of Bengal, Vol. III. 1834; Vol. IV. 1835; Vol. V. 1836.

Proc. Bost. Soc. Nat. Hist.—Proceedings of the Boston Society of Natural History, Vol. I. 1843-44, (not accessible in Calcutta).

Gould, Ot. Conch.—Augustus A. Gould, Otia Conchologica, descriptions of shells and mollusks from 1839 to 1862, Boston, 1862.

S. Hanley, Supp. to Wood's Ind. Test.—Supplement to Wood's Index testaceologicus, 1855 (not accessible in Calcutta).

Genus UNIO, *Retzius.*

I.—India.

No. 1.—Unio corrugatus, Müll. sp. Rivers of Coromandel.

Mya corrugata, Müll., p. 214, No. 398.
Unio corrugata, [*a*,] Lam., VI., 78, No. 34.
U. corrugatus, Küster, Mart. and Chem., p. 289, pl. 97, figs. 3, 4.

There is the greatest conceivable confusion about this species and the next one, and it is far from clear what Müller's type was. I cannot obtain access to his work in Calcutta, but Küster copies the description thus:—

Testa rhombea, viridescens, tenera, pellucida ; (umbonibus corrugatis ;) valvulæ intus striis radiantibus subtilissimis notantur.

The figures are, I suppose, those of Chemnitz's types; they are two in number, one representing the exterior of a subequilateral, nearly elliptical shell, measuring 36 mm. by 24 in its two diameters, and the other the interior of a far more inequilateral shell, also subelliptical, rather smaller than the first, and having every appearance of being a

thick form, with strong lateral teeth. The first shell is subalate posteriorly, and the posterior margin is very bluntly biangulate, the anterior margin is rounded at the end, but the slope thence to the umbo is almost a right line; the second shell is perfectly rounded both before and behind. The shell of which the interior is figured corresponds so ill with Müller's description, being neither rhombic nor thin, that it may certainly be neglected. The figure moreover is ill-executed.

Lamarck's description is a little different from Müller's: "*Unio testâ ovato-rhombeâ, tenui, viridi, umbonibus rugosis, rugis undulato-flexuosis sublongitudinalibus.* Of the variety *a* he adds *testa viridis, pubis cariná lævigatâ.* His variety *b* is said to be the next species, *U. rugosus.*

The type shell in Mons. de la Serre's cabinet in Paris, which, by the politeness of M. Chenu, the Curator, I was enabled to examine in 1862, is a thin broadly ovate form with small teeth, and a well marked posterior wing. It measures 40 mm. from anterior to posterior margin, and 33 from the umbo to the ventral margin, the latter diameter being thus much greater in proportion to the former than in Küster's type. The valves are inequilateral and much broader behind than before, the anterior margin rounded, sloping away below to the ventral side; posterior margin bluntly biangulate, the two angles rather wide apart. The form is common in Southern India and Ceylon, and appears to have been generally accepted as the type.

Both Lamarck's and Chemnitz's types are quite distinct from Benson's *U. favidens*, which has been confounded with them.

No. 2.—Unio rugosus, Gmelin. Rivers of Coromandel.

Mya corrugata magna, Chemn. Conch. Cab. X. 346, Pl. 170, f. 1659.
M. rugosa, Gmel. p. 3222, No. 32.
Unio corrugata, [*b.*], Lam. VI., 78, No. 34.
Unio rugosus, Küster, Mart. and Chem. p. 290, Pl. 97, f. 5.

Both this and the preceding species probably inhabit the Cauvery or neighbouring streams. Küster's figure represents an elliptical subequilateral shell, with strong angulate sulcation at the umbones, extending to within no great distance of the ventral margin. Gmelin's original description is the following :—

M. testâ ovali rugosâ, extrinsecus virescente, intus margaritaceâ: cardinis dente primario crenulato, laterali longitudinali, alterius duplicato.

No. 3.—Unio marginalis, Lam. Bengal.

Lam. VI. 79, No. 41.
Küster, Mart. and Chem. p. 239, Pl. 80, f. 4.

This species is probably the most widely distributed of all the Indian forms. It is extremely variable, and I am inclined to believe that many of the species to be hereafter enumerated are merely varieties of it. I have examined the type and compared a shell from Pegu with it, which will be figured. It agrees very well. Küster's figure represents a variety with unusually prominent umbones, and rather longer from the hinge to the ventral margin than usual.

U. marginalis is by no means confined to India. It abounds, as I have already mentioned, in Pegu. One of Lamarck's forms came from Ceylon, and Küster appears much disposed to unite to it a species from the Nile in Egypt. Lamarck's type was said to inhabit rice-fields in Bengal.

No. 4.—Unio anodontinus, Lam. Bengal.

U. anodontina, Lam. VI. 80, No. 47.
U. anodontinus, Küster, Mart. and Chemn. p. 240, Pl. 80, f. 5.

Lea has classed this shell as identical with *U. marginalis*, Lam. If Küster's figures in the Conchylien Cabinet can be trusted, the two shells differ more than any one of Lea's three species, *bilineatus*, *lamellatus*, and *Bengalensis* do from each other, or from *marginalis*. Most of the Bengal specimens of *marginalis*, however, are intermediate between the two forms figured by Küster as *marginalis* and *anodontinus*.

The locality given by Lamarck for this species is Virginia. I unfortunately omitted to examine the specimen when I had the opportunity of doing so. There is, I believe, no question but that the shell was really from India.

No. 5.—Unio favidens, Bens. Ganges valley and Burhampooter valley, Assam.

Benson, Gleanings in Science, I, Pl. 8, f. 1.
" Ann. Mag. Nat. Hist. 1862, 3rd Ser. X. 188.

This species has been frequently confounded with *U. corrugatus*,

Lam. It differs totally from all the shells referred to that species, and all its numerous varieties are easily distinguished both from Lamarck's and Chemnitz's types of *corrugatus*. *U. favidens* is more inequilateral, it is a thicker shell with much stronger and broader cardinal teeth. The type, too, is more angulate, both anteriorly and posteriorly. The following varieties of *U. favidens*, with their localities, are described by Mr. Benson in the Ann. and Mag. Nat. Hist. Vol. X, pp. 188, 189.

Unio favidens, type. Bhitoura on the Ganges between Cawnpore and Allahabad.

1 *var. marcens*,........Burhampooter river, Assam.
2 ,, *trigona*, ...Nujeebabad in the north-west of Rohilkund.
3 ,, *Deltæ*, ...Jellinghy river, Bengal.
4 ,, *Chrysis*, ...Dojora river, Kareily Ghat near Bareilly.
5 ,, *viridula*, ..."Jheel" between Humeerpore and Someerpore, Bundelkund.
6 ,, *densa*, ...Ganges river above Chunar.

No. 6.—Unio Cæruleus, Lea.—Hoogly river, 100 miles above Calcutta.

Lea, Trans. Am. Phil. Soc. IV, 95, Pl. 13, f. 25.
Benson, J. A. S. B. IV. 450.
Küster, Mart. and Chem. p. 228, Pl. 77, fig. 4.

The two figures agree perfectly. The type is a very thin shell, with fine lamellar teeth. Specimens exist in the Asiatic Society's Museum, brought from Bhagulpoor. The form is widely distributed in N. India; I have even a variety from Sind.

No. 7.—Unio bilineatus, Lea. Hoogly river with the last.

Symphonota bilineata, Lea, Trans. Am. Phil. Soc., IV. 98, pl. 11, f. 19.
,, Benson, J. A. S. B. IV. 452.

Benson, (Ann. Mag. Nat. Hist. Ser. 3, Vol. X., pp. 187, 195) shews that this is merely the very young form of *U. marginalis*, Lam. He is unquestionably correct. The "two delicate lines passing from the beaks to the posterior region" are, like many other umbonal markings, characteristic of young shells, and disappear gradually with age. The remains of them, much blunted, are often to be detected on adults.

No. 8.—Unio olivarius, Lea. Ganges valley.

Lea, Trans. Am. Phil. Soc. IV, 108, pl. 16, f. 38.

Benson, J. A. S. B. IV. 453.

Küster, Mart. and Chem., p. 244, pl. 82, f. 2.

The locality given by Lea is Burrill river, India. Küster, who appears to be indebted for all his Indian species described by Lea to Dr. von dem Busch, gives Burrill river, Indiana (!), North America, as the locality. Mr. Benson says—"It is widely distributed in the Gangetic region, and is most abundant in the Rohilkund streams." The variety figured by Küster differs from Lea's type is being more inequilateral, much shorter anteriorly, and more obtuse posteriorly, and of a light green colour instead of pale olive. Indeed, it is by no means clear that the specimen figured is not a variety of *U cæruleus*. I do not know if there be such a river as the Burrill, but the locality for the original type is very probably the neighbourhood of the Burail Range, north of Cachar, as the shell was received by Lea from a Dr. Burrough who collected extensively in Assam, and who supplied the original specimens, from which *Hylobates Hoolock* was described, to Dr. Harland.* This is not far from the localities whence the closely allied *U. Nuttallianus*, Lea, and *U. involutus*, Benson, were obtained.

No. 9.—Unio Corrianus, Lea. Calcutta.

Lea, Trans. Am. Phil. Soc. V. 65, pl. 9, fig. 25.

Küster, Mart. and Chem., p. 229, pl. 77, fig. 5.

Two completely distinct shells are figured by the two authorities above referred to. Lea's original type is a young form of one of the common varieties of *marginalis*, approaching *U. anodontina* of Lamarck; Küster's, on the contrary, is a form allied to *U. cæruleus*, but thicker, and with broader hinge teeth than that species, so that it is more diverse from *U. marginalis* than even *cæruleus* is! Küster's specimen was derived from Dr. von dem Busch, who, in this and other instances, appears to have utterly confounded different forms.

* See Transactions of the American Philosophical Society, Vol. IV. p 52. It is a disgrace to the science of England as represented in British India, and a lasting memorial of the disregard of natural history which has always been a characteristic of the British Government of India, that so remarkable an animal as the Hoolock should have been first recognised by an American naturalist at so late a date as 1834. Had India belonged to France, the United States or Russia, the study of its fauna would not have been left to the unaided efforts of private individuals.

No. 10.—UNIO BENGALENSIS, Lea. Bengal.

Lea, Trans. Am. Phil. Soc. VI. 3, pl. 2, f. 3.
Küster, Mart. and Chem., p. 228, pl. 77, f. 2, 3.

In this case again, two totally distinct shells are figured, and again the authority for Küster's appears to be Dr. von dem Busch, whose collection furnished the specimen figured in Martini and Chemnitz. Lea's type is a very peculiar variety of *U. marginalis*, very much "longer" (that is wider when measured from the umbones to the ventral margin) in proportion to the breadth than usual. I have not met with it. It was obtained by Lea from Dr. Burrough who purchased it in Calcutta, and believed that it inhabited the Ganges. It has better claims to distinction than most of Lea's "species."*

Küster's type is a much thicker, more tumid shell, with far stronger teeth and impressed cicatrices, much more inequivalve and different in almost every character. I cannot recognise it as any form with which I am acquainted, and I much doubt its being Indian at all. At all events it is nearer to *U. corrugatus* than to *U. marginalis*.

No. 11.—UNIO LAMELLATUS, Lea. Bengal.
Lea, Trans. Am. Phil. Soc. VI. 19, pl. 6, f. 16.

This is another variety of the *U. marginalis* type, perfectly intermediate between the two last named, and approaching the type more nearly than either. Lea's shells were probably immature. In the younger shells of *marginalis*, the hinge teeth are more lamellar than in the adults, and the principal character of this "species" and of the two preceding is the lamellar teeth.

I have not met with the exact type of this shell, but it doubtless inhabits the neighbourhood of Calcutta. Specimens resembling it in every way except in being rather less long (in the dorso-ventral diameter) in proportion to their breadth are common.

No. 12.—UNIO RAJAHENSIS, Lea. Rajah's Tank, Calcutta.
Lea, Trans. Am. Phil. Soc. VIII., 239, pl. 23, fig. 53.

The above is the locality quoted. I am unable to discover what

* In a letter to my brother, Mr. Benson suggested a doubt as to whether this species were Indian. Taking into consideration the circumstance that nearly all the shells in the Calcutta bazar are foreign, this suggestion appears highly probable.

tank is referred to. The shells inhabiting the Seven Tanks shew a considerable difference. The shell is a small, subrotundate, thick form, approaching some of the varieties of *U. favidens*, Bens., and has much the appearance of being stunted and distorted, a very common occurrence in tanks, and especially in those of Calcutta, probably in consequence of their being slightly brackish at times. Two specimens, agreeing well with Lea's figures, exist in the Asiatic Society's Museum. A very similar shell inhabits the Nerbudda.

No. 13.—Unio Shurtleffianus, Lea. Sina River, India.

Lea, Jour. Acad. Nat. Sci. Phil. III., 302, pl. 27, f. 17.

The Sina river runs past Ahmednugger in the Deccan. It is an affluent of the Bheema, one of the principal feeders of the Kistna. This shell has somewhat the form of *Unio cæruleus*, but is thicker. Unfortunately the volume containing the description of this shell does not appear to exist in Calcutta, so I cannot tell whether specimens, which I possess from the neighbourhood, belong to the type form or not. In such extremely variable shells as *Unio* this is a matter of considerable importance.

No. 14.—Unio Merodabensis *v. d. Busch, Province of Merodab in Bengal.* (!)

v. d. Busch. MS. in Küster, Mart. and Chem., p. 233, pl. 78, fig. 4.

I give the locality of this ridiculously named species as it is quoted in Küster. The locality is doubtless Moradabad in Rohilcund. Küster gives as a synonym *? U. flavus*, Benson, and adds the remark: "Whether this species be Benson's described *U. flavus*, I cannot ascertain, as I have not access to Benson's work. The name would be ill-selected, as the shell is by no means yellow."

Of course Benson's species thus referred to is *U. favidens*, of which the present appears to be a variety, very close to Mr. Benson's *var. trigona.* The name *Merodabensis* is so utter a barbarism, that it will be satisfactory to be rid of it. For the little series of blunders attending the description of this type, Dr. v. d. Busch again appears to be responsible.

No. 15.—Unio Sikkimensis, Lea. Sikkim.

Lea, Jour. Acad. Nat. Sci. Phil. 2nd Ser. IV. 251, pl. 39, f. 131.

I have some doubt about the locality assigned to this species. It

approaches the S. Indian forms of the *corrugatus* type (Lamarck's) in outline, and is barely distinguishable from two shells in the Asiatic Society's collection, which are labelled from Ceylon. It is a stouter shell than the Lamarckian *corrugatus.**

No. 16.—UNIO NAGPOORENSIS, Lea. Ambajiri tank, Nagpoor.

Lea, Jour. Acad. Nat. Sci. Phil. Ser. 2, IV. 270, pl. 45, f. 150.

This species is barely separable from some varieties of *Unio favidens*, Bs. It is, however, a rounder, thinner shell, forming a link, both in character and locality, between that species and *Unio corrugatus.*

No. 17.—UNIO WYNEGUNGAENSIS, Lea. Wynegunga river, east of Nagpoor.

Lea, Jour. Acad. Nat. Sci. Phil. 2nd Ser. IV, 271, pl. 45, f. 151.

Except in greater thickness, and stouter hinge teeth, there appears no distinction of the slightest importance between this "species" and the last. The type abounds in the Godavery and its feeders, and is, as usual, variable. The locality given by Lea is Wynegunga river, East of Nagpoor in the Deccan, Bengal, which is equivalent to talking of Philadelphia in New England, Virginia. However it is hardly fair to expect American naturalists to have accurate information on Indian geography, when an English naturalist of repute confounds the Khasi hills in N. E. India with the Nilgiris in the S. W., and when a second, in a work solely devoted to Indian zoology, perhaps the most important work on any branch of Indian Natural History, exclusive of botany, ever published in England, confounds Saharunpoor with Serampoor on the Hooghly. After this, the discovery made by the *Times* newspaper, a few years ago, that a spur of the Himalayas is visible from Calcutta is not so surprising. A distinguished French naturalist, five or six years since, placed Kattiawar in Cochin China, but it is only fair to add that this was before the French expedition to the latter country, and that French naturalists have already done not a little towards making us better acquainted with the Molluscan fauna of that little known region.

* Since writing the above, I have learned that the locality is correct. The shell was collected by Dr. Bacon.

No. 18.—UNIO THECA., Bens. River Cane near Banda, Bundelcund.

Benson, Ann. and Mag. Nat. Hist. 1862, 3rd Ser. X. 186.

I have not seen this form. It belongs, according to Mr. Benson, to the *Corrianus* type of *Unio marginalis.*

No. 19.—UNIO MACILENTUS, Bens. Choia Nuddy, near Bijnore, Rohilcund.

Benson, Ann. and Mag. Nat. Hist. 1862, 3rd Ser. X. 187.

A rather thin species resembling *cæruleus,* but with stout hinge teeth, resembling those of *U. favidens.* I am unacquainted with the type, but a very similar form is common in the Damuda and its tributaries in Bengal.

No. 20.—UNIO TRIEMBOLUS, Bens. R. Ramgunga, near Moradabad.

Benson, Ann. and Mag. Nat. Hist. 1862, 3rd Ser. X. 190.

A thick shell with large hinge teeth. A massive species which inhabits the Nerbudda, and the shells of which are found fossil associated with the bones of extinct mammalia in the gravels of the river valley, may be a variety of this species. I have never seen the type.

No. 21.—UNIO PLAGIOSOMA, Bens. River Cane near Banda, Bundelcund.

Benson, Ann. and Mag. Nat. Hist. 1862, 3rd Ser. X. 191.

No. 22.—UNIO LÆVIROSTRIS, Bens. Near Chunar, in streams and tanks.

Benson, Ann. and Mag. Nat. Hist. 1862, 3rd Ser. X. 191.

No. 23.—UNIO PINAX, Bens. Gungun stream, near Moradabad, Rohilcund.

Benson, Ann. and Mag. Nat. Hist. 1862, 3rd Ser. X. 192.

The three abovenamed species appear all to be allies of *U. favidens.* They probably pass into each other.

No. 24.—UNIO LEIOMA, Bens. Deccan? near Bombay.

Benson, Ann. and Mag. Nat. Hist. 1862, 3rd Ser. X. 192.

The locality of this shell is uncertain. I have no species from Western India which agrees with the description.

No. 25.—Unio occatus, Lea. Bengal.

Lea, Jour. Acad. Nat. Sci. Phil. 2nd Ser. V. 398, Pl. 50, fig. 304.

A compressed form, with strong teeth, fairly intermediate between *cæruleus* and *favidens*, and allied to *U. macilentus*, Bs. and *U. plagiosoma*, Bs. but more compressed than either. It especially requires comparison with *U. macilentus*, of which it may be a compressed form.

No. 26.—Unio Gerbidoni, Eydoux. Coromandel.

Said by Lea to be the same as *Unio cæruleus.*

No. 27.—Unio Bonneaudi, Eyd. South India.

No. 28.—Unio Gaudichaudi, Eyd. Bengal.

No. 29.—Unio Keraudrenii, Eyd. Chandernagore.

I am indebted for all my information as to the above four species to Mr. Benson. I have not access at present to the work in which they are described.

In Küster's monograph of *Unio* in Martini and Chemnitz another species is described from the "East Indies," *U. Exanthematicus*, Küster, p. 243, pl. 81, fig. 2. The authority, however, for the locality is Dr. v. d. Busch, whose general accuracy, after the instances given above, may be open to doubt; the "East Indies" in a Natural History sense, not many years since, denoted any country between Africa and Kamschatka, and the peculiar pustulated surface of the shell, from which the name is derived, is unknown in any Indian species. I think it is probably not a native of the Indian Peninsula.

U. discus, Lea, Trans. Am. Phil. Soc. IV, 74, *Pl.* 18, *f.* 57, was at first stated to be from India, on, however, palpably insufficient grounds, the original specimen having been purchased from a dealer amongst a lot of shells from India. The shell is so distinct from any known Indian species, that I had concluded that the locality was assigned to it in error, before I found that in a subsequent volume of the Trans. Am. Phil. Soc., Vol. VIII., p. 234, note, Lea mentions his having ascertained that the locality was the River Moctezuma in Central America.

Mr. Benson mentions (Ann. and Mag. Nat. Hist. 1862, X., 195,) his having received from the Malabar Coast a shell which he refers to *U. consobrinus*, Lea.

Unio spuria is said by Lamarck to be from Southern Asia. Mr. Benson states (Ann. and Mag. Nat. Hist. 1862, X., 189,) that the young of *U. favidens* approaches the figure given by Wood of *Mya spuria*, which is, I suppose, the same species. It is not clear that Lamarck's type was Indian. Mr. Benson also (l. c. p. 189) refers to *Mya radiata*, Chem. as being from Malabar. *Mya radiata*, Gmelin is by Lamarck, Lea and Küster, said to be American, and even in Küster I can find no allusion to Chemnitz's species.

It is only right to add too that some of what Woodward most justly terms "the worthless fabrications of Rafinesque" (Man. Mol. p. 136, note,) came from India. No scientific purpose can be served by recalling the names from the oblivion in which they are happily buried.

II.—Assam.

No. 30.—Unio involutus, Benson. Assam.

S. Hanley, Supp. to Wood's Ind. Test.

I only know of this and the succeeding three species from reference being made to them by Mr. Benson in the Ann. and Mag. Nat. Hist. for 1862, 3rd Ser. X., 186. The work in which they were originally described is not procurable in Calcutta. *U. involutus* is said to be thin and tumid and to represent *U. olivarius*, Lea, in Assam.

No. 31.—Unio Corbis, Bens. Assam.

S. Hanley, Supp. to Wood's Ind. Test.

No. 32.—Unio Radula, Bens. Assam.

S. Hanley, Supp. to Wood's Ind. Test.

No. 33.—Unio Scobina, Bens.

S. Hanley, Supp. to Wood's Ind. Test.

U. fluctiger, Lea (teste Benson) Jour. Acad. Nat. Sci. Phil. 2nd Ser. IV. 250, pl. 39, f. 130.

„ Küster, Mart. and Chem., p. 237, pl. 80, fig. 1.

Mr. Benson (in Ann. and Mag. Nat. Hist. 1862, X., 186) states that *U. fluctiger*, Lea, is a synonym of *U. Scobina*. Küster's figure of *fluctiger* differs from Lea's type, and the shell is stated to be from S. America. As, however, Küster's specimen was from Dr. v. d. Busch's cabinet, very little reliance can be placed upon the assigned locality, especially as Lea, who did not know whence the shell came, suggested that it was, possibly, South American.

Küster's type is narrower anteriorly and has rather different, coarser plication posteriorly, than Lea's. It may be a different shell.

No. 34.—Unio Nuttallianus, Lea. Assam, teste Benson.

Lea, Jour. Acad. Nat. Sci. Phil. III., 310, pl. 30, f. 25.

The locality is simply stated to be India by Lea. Benson, Ann. and Mag. Nat. Hist. 1862, X., 194, states that he has received specimens from Assam. The volume containing the description of this shell is not procurable in Calcutta.

No. 35.—Unio Jenkinsianus, Bens. Burhampooter River, Assam.

Benson, Ann. and Mag. Nat. Hist. 1862, 3rd Ser. X., 185.

An ally of *U. marginalis*, distinguished by "the very tumid form, the sloping posterior end, absence of a wing, the short ligament, and the nature and position of the teeth." (Bens. l. c.) In the Asiatic Society's collection there is a shell from Bhagulpoor perhaps referable as a variety to this species.

No. 36.—Unio pachysoma, Bens. Burhampooter River, Assam.

Benson, Ann. and Mag. Nat. Hist. 1862, 3rd Ser. X., 186.

"An inflated form of the *cæruleus* type." (Bens. l. c.) Mr. Benson also states that he has received a distorted variety from Calcutta. A peculiar tumid form which is not uncommon in Calcutta tanks is doubtless referred to. It agrees generally with the description given. This form therefore adds one more to the Bengal list.

No. 37.—Unio Smaragdites, Bens. Burhampooter River, Assam.

Benson, Ann. and Mag. Nat. Hist. 1862, 3rd Ser. X., 190.

A shell allied to *U. favidens*.

Besides these forms a variety of *U. favidens*, Bens. (*var. marcens*) has already been quoted as occurring in Assam. Mr. Benson also records the receipt of a variety of *U. cæruleus* (J. A. S. B. VI. 750) and of a small variety of *U. marginalis* (Ann. and Mag. Nat. Hist. 3rd Ser. X. 186) from that region.

III.—Ceylon.

No. 38.—Unio Layardi, Lea. Ceylon.

Lea, Jour. Acad. Nat. Sci. Phil. 2nd Ser. IV., 243, pl. 36, f. 122.

This is a shell of the *marginalis* type with a convex dorsal margin, and generally rounded outline. It appears to be a fairly distinguishable form, though very close to *Bengalensis* and *lamellatus*.

No. 39.—Unio Thwaitesii, Lea. Ceylon.

Lea, Jour. Acad. Nat. Sci. Phil. 2nd Ser. IV., 246, pl. 37, f. 125.

This shell only differs from the last in having a rather straighter hinge line, and being slightly more inequilateral. If such differences are to rank as specific, half a dozen "species" might be manufactured out of any tank in Calcutta. The separation of these two forms is perfectly unjustifiable in a genus like Unio.

The above are the only species that I can trace specially described from Ceylon. Lamarck's variety *b.* of *Unio marginalis* described as *var. testâ minore, breviore*, and 75 millimetres broad was also from Ceylon (Lam. VI. 79). Sir Emerson Tennent, in his work on Ceylon, enumerates only *U. corrugatus* besides *U. marginalis*. He, however, adds that Mr. Cuming possessed six species from the island, which had been sent to Mr. Lea. *U. Thwaitesii* and *U. Layardi* are doubtless two of these, as they were from Mr. Cuming's cabinet, but no mention is made of the others by Mr. Lea.

IV.—Burma.

No. 40.—Unio Tavoyensis, Gould. Tavoy.

Gould, Proc. Bost. Soc. Nat. Hist. I., 140.
" Ot. Conch. p. 190.
Küster, Mart. and Chem., p. 166, pl. 48, f. 2.

"Closely allied to *U. corrugata*, Lam. which is less rounded and less corrugated" (Gould, l. c.) More nearly allied to Lamarck's than to Chemnitz's type of *U. corrugatus*. Küster's figure agrees well with Gould's description, but represents a young shell, not mature. The specimen figured was from the collection of Dr. Sturm (and not from that of Dr. v. d. Busch).

No. 41.—Unio crispatus, Gould. Tavoy.

U. crispata, Gould, Proc. Bost. Soc. Nat. Hist. I., 141.
" " Ot. Conch. p. 191.

No. 42.—Unio foliaceus, Gould. Tavoy.

U. foliacea, Gould, Proc. Bost. Soc. Nat. Hist. I., 141.
" " Ot. Conch. p. 191.

An ally (variety ?) of *U. marginalis*, Lam. "Closely allied to *U. Bengalensis* and *Corrianus*, Lea." (Gould, l. c.)

No. 43.—Unio exolescens, Gould. Tavoy.

Gould, Proc. Bost. Soc. Nat. Hist. I., 141.
„ Ot. Conch. p. 191.

Apparently, from the description, another ally or variety of the *U. marginalis* type.

No. 44.—Unio generosus, Gould. Tavoy.

Gould, Proc. Bost. Soc. Nat. Hist. II., 220.
„ Ot. Conch. p. 201.

I believe I possess this species. Specimens were sent to me by Mr. Theobald from Pegu, which agree with the description fairly, except that they are smaller than the type.

No. 45.—Unio luteus, Lea. Newville, Tavoy.

Lea, Jour. Acad. Nat. Sci. Phil. III., 302, *pl.* 27, 17.

I have not access to the description or figure of this species.

No. 46.—Unio crispisulcatus, Bens. Bangong R. near Thayet Myo, Pegu.

Benson, Ann. and Mag. Nat. Hist., 1862, 3rd Ser. X., 193.

I am indebted to Mr. Theobald for specimens of this shell. It appears doubtful whether it be more than a variety of *U. crispatus*, Gould, to which Mr. Benson does not refer in his description, and with which he was possibly unacquainted. Gould's description is very brief, and gives the idea of a more coarsely sculptured shell ("*rugis angulatis radiantibus undique crispata*") besides being somewhat shorter (from the dorsal to the ventral margin) in proportion to its breadth, but these are not necessarily specific distinctions.

No. 47.—Unio Pugio, Bens. Ava and Pegu.

Benson, Ann. and Mag. Nat. Hist., 1862, 3rd Ser. X., 193.

A solitary valve was sent to Mr. Benson by Mr. Theobald, who gave the locality as Ava. I subsequently found the same form in the Myanoung district of Pegu, and Mr. Theobald has since obtained larger varieties, I believe from Prome. It is a well marked type, extremely inequilateral, and with a peculiar acuminate form posteriorly.

As already observed, the type form of *Unio marginalis*, Lam. abounds in Pegu. I found unusually fine specimens in large swamps about Henzada and Myanoung in the Irawady valley. The type gradually passes by insensible gradations into a much less transverse

form, almost subquadrate. The posterior portions of the valves were often covered by the remarkable fresh water Bryozoon *Hislopia* of Carter, apparently a new species.

I have other species from Pegu, but I am unable at present to compare them with the numerous named forms described by Lea from Siam, many of which probably extend to Burma.

Genus ANODONTA, Brugiere.

No. 1.—ANODONTA SOLENIFORMIS, Bens. Assam.

Benson. J. A. S. B. V., 750.

The type specimen is in the Asiatic Society's Museum (now the Imperial Museum). There is also an *A. soleniformis*, D'Orbigny, but Mr. Benson's name is the oldest, as it was published in 1836.

Mr. Lea has described a species from Siam, evidently very closely allied to this, as *Mycetopus emarginatus*, Lea. (Jour. Acad. Nat. Sci. Phil. 2nd Ser. V., 398, pl. 50, f. 305). As the animal has not been observed, it may be doubtful if it is really a *Mycetopus*. At the same time the character of both the Siam and Assam shells are so distinct from those of any true Anodonta, that perhaps the best provisional classification is that adopted by Mr. Lea. Specimens of *A. soleniformis* with the animal living are a peculiar desideratum.

No. 2.—ANODONTA SALWENIANA, Gould. Salween R., Burma.

Gould, Proc. Bost. Soc. Nat. Hist. I., 158.
„ Ot. Conch. p. 193.

A very peculiar broad shell, belonging to *Monocondylæa*. (See next species.) I have never seen this form.

No. 3.—ANODONTA INOSCULARIS, Gould. Salween R., Burma.

Gould, Proc. Bost. Soc. Nat. Hist. I. 158.
„ *Ot. Conch. p. 193.*

Subsequently in the same volume, p. 161, Dr. Gould suggested that this species might be the type of a new genus which he named *Pseudodon*. This name is by Adams quoted as a synonym of *Anodonta*, but the type species is not quoted under that genus, nor, so far as I can detect, under any other. In *Otia Conchologica*, Gould, in describing the genus, adds in brackets "perhaps equivalent to *Monocondylæa*, D'Orb." So far as the shell is concerned, this is undoubtedly the

correct position of these species, if the hinge teeth are trustworthy indicators of generic affinity. H. and A. Adams, in the Gen. Rec. Moll., include under *Monocondylæa*, *M. Vondenbuschiana*, Lea, from Java,* described by Lea as a *Margaritana* (*Baphia* of Adams) and several species of the genus have been described from Siam and Cochin China by French and American naturalists.

I have received from Mr. Theobald fine specimens obtained in Pegu which correspond admirably with *Margaritana Vondenbuschiana*, Lea, and unquestionably belong, I think, to that species; and also shells which appear to belong to a variety of *Anodonta inoscularis*, agreeing with the type in size, shape and every character of importance; and not only are the two forms unmistakeably congeneric, but I even think it probable that specimens might be met with to unite them specifically, as they differ in no essential character, except the very different degree of development of the cardinal tooth, which in *Vondenbuschiana* is scarcely raised, while in the specimens which I refer to *inoscularis* it is sometimes nearly a quarter of an inch high.

There are in the Asiatic Society's collection, also, two forms which appear to me certainly varieties of *M. Vondenbuschiana*. One of them, however, agrees more closely with the figure of *M. Cumingii*, Lea (Jour. Acad. Nat. Sci. Phil. 2nd Ser. IV, 235, pl. 33, f. 114) a Malacca shell, which only differs from *Vondenbuschiana* in unimportant minutiæ.

M. Vondenbuschiana is described and figured by Lea in Trans. Am. Phil. Soc. VIII, 222, pl. 18, f. 39, and also in Küster.

Were there nothing but the form of the hinge teeth to connect the South American species of *Monocondylæa* with the Burmese and Javanese *Pseudodon* and *Margaritana*, especially having regard to the very diverse form of the shell, I should suspect them to be in reality distinct types. But there is one little peculiarity which appears to tend to unite them. At the termination of the portion of the hinge line in which, by close inspection, flattened obsolete representations of the lateral teeth may be seen, there is a very peculiar expansion of the end of the ligament which covers a small sinus in the inner surface of both valves. This is very well shewn in Lea's figure of *Margaritana*

* Yet they state, "All the species of this genus known are from the rivers of South America."

Vondenbuschiana, and also in both Adams's figures of different species of *Monocondylæa* from S. America. The same occurs in Anodon and in the type species of *Margaritana* of Schumacher,* (*M. margaritifera*, L.). I have not had an opportunity of examining the animals of the Burmese species of *Monocondylæa*, and therefore cannot say if the gills are free or not.

Besides the above forms, a minute species of *Anodon* is stated by Mr. Benson to inhabit ponds in Bundelcund, J. A. S. B., V. 750.

P. S. No. 2*a*.—Unio spurius, Gm. Tranquebar.

Mya spuria, Gm. vol. I, Pt. VI, p. 3222, No. 16.

Unio spuria, Lam. VI, 80, No. 45.

Mya spuria, Wood, Ind. Test. p. 12, pl. 2, No. 35.

Since writing the note on this species at p. 146, I have found that it was described originally as from India. Gmelin refers to Schroeter Einl. in Conch. II, 617, No. 9, pl. 7, f. 5, so perhaps the name may have been given by Schroeter, though that by no means follows from the reference. The description is very brief: "*M. testâ rhombeâ viridi, natibus glabris*" and the shell is said to be like *corrugatus*, but nearly twice the size and perfectly smooth in front of the beaks ("*praeter vulvæ regionem tota glabra*," Gm. *l. c.*). Wood's figures are all poor. The shell can scarcely be a young form I think, if considerably larger than *corrugatus*.

Mya radiata,† I find, is attributed to Malabar by Gmelin, (p. 3220,) from whom Wood appears to have only copied his localities. The species is, I think, correctly attributed to Chemnitz by Mr. Benson, although other authors give Gmelin as their authority. Gmelin's description runs thus—"*M. testa æquivalvi pellucida tenuissime transversim striata viridi flavicante livido radiata ; valvis altero latere latissimis, altero angustissimis.*" I know of no form of Indian *Unio* to which this description would be applicable, and I cannot help suspecting that the writers who have applied the name to an American species may very possibly be right. Wood's figure, also, does not recall any Indian

* It is by no means clear that *Margaritana* and *Monocondylæa* are more than subgenera, or even artificial sections of *Anodonta*. *M. Vondenbuschiana* is intermediate between the second and last in characters of the shell, and there is no known essential distinction in the animal.

† The Linnæan genus *Mya*, like most Linnæan genera, was an artificial group to some extent Besides *Mya* as now understood, it comprised *Unio* and several other genera.

species; for it is evident from the above description that the radiating lines shewn do not refer to striæ but to coloured markings. Mr. Benson's shell from Malabar was striated.

Good collections of the Unios of both Coromandel and Malabar are greatly needed to determine all these doubtful species.

MONOCONDYLÆA CREBRISTRIATA, Anthony. Pegu.

American Journal of Conchology, I., 205, pl. 18.

MONOCONDYLÆA PEGUENSIS, Anthony. Pegu.

Am. Jour. Conch. I., 205, pl. 18.

I am indebted to Mr. Theobald for the above quotations. The shells are the two *Monocondylæa* above referred to, the first being that referred by me, though with some doubt, to *Anodonta (Pseudodon) inoscularis*, Gould, the second to *Monocondylæa Vondenbuschiana*, Lea. So long as it is the practice of naturalists living in foreign countries, and, necessarily, imperfectly acquainted with the fauna of distant regions, to give a "specific" name to every animal or fragment of an animal which reaches them, lists of synonyms must multiply; and as everybody will contend for the distinctness of his "species," false notions as to the nature and value of specific distinctions must prevail. Thus, in the same paper, one of the numerous varieties of *Melania variabilis*, Benson, is called *M. gloriosa*, Anthony. Now it is worthy of remark that Mr. Benson, who has examined far more of the Mollusca of Burma than Mr. Anthony can possibly have seen, has not for years described a single Melania from that country as new, and has only described two species of Unio, although he had specimens of all Mr. Anthony's supposed new species. I can only add that it would be easy for me to describe, from the materials I possess, 20 or 30 forms of *Unio* (and nearly as many more of *Melania*) with as good claims to distinction as one-half at least of those already published from India and Burma; but were I to do so, I cannot help thinking that, while burdening science with additional names, I should have added nothing to the knowledge of the fresh water mollusca of India. Amongst fresh water shells I am convinced that forms pass into each other far more than amongst land shells, that "species," in the usual definition of the word, have no existence, that all the characters relied upon for distinguishing "species" of *Unionidæ* in especial, the form and thickness of the hinge teeth, form

of the shell, prominence of the umbones, shape of the muscular impressions, colour of the nacre, characters of the epidermis, &c. vary *ad infinitum*—in short that species must be described like genera and grouped around types, not distinguished by characters.

I see from a notice in the Paris *Journal de Conchyliologie* that, in the same volume of the American Journal of Conchology, Mr. Conrad proposed a new genus *Trigonodon* for *Monocondylæa crebristriata* of Anthony, from which, as I have stated above, *Anodonta inoscularis*, Gould, is at the best but dubiously separable specifically. But the last named shell is the type of Gould's genus *Pseudodon*, and Gould himself suggested the identity of that genus with D'Orbigny's *Monocondylæa*.* Unless Mr. Conrad has procured the animals of the Pegu forms, and shewn them to be distinct from those of South America, (and I scarcely think he can have done so,) I cannot believe that any useful object is attained by inventing these generic appellations. Even if *Trigonodon* be not *Pseudodon* over again, (Mr. Conrad appears to have already furnished one synonym before for *Pseudodon*, viz. *Monodontina*,) there has been no distinction of any generic value shewn between the shells of Burmese and Malay species of *Monocondylæa* and those of S. America; and bearing in mind that there are some genera of more restricted distribution than those belonging to the *Unionidæ*, *e. g.* the Tapir, and amongst Mollusks, *Cyclophorus* and *Megalomastoma*, common to the two regions, it would, I think, be more scientific to examine the animals of the Burmese shells allied to *Monocondylæa*, before founding new genera to comprise them.

There is of course the possibility that Mr. Theobald may have been misinformed as to the respective names of the two species, and that the type of *Trigonodon* is the form I have referred to *Monocondylæa Vondenbuschiana*. I can only add that the specimens of the same shell from the same locality sent to me by Mr. Theobald, do not differ more from Küster's figure of V. d. Busch's original specimen of *M. Vondenbuschiana* in Martini and Chemnitz, than that figure does from Lea's.

Unio Peguensis, Anthony.

American Journal of Conchology, Vol. I.

I cannot learn what species has been thus named I hope to be able to refer to the volume before long and to return to the subject.

* Ot. Conch., p. 194.

Two Indian species of *Unio* in the Musée d' Histoire Naturelle at Paris have received MS. names from Valenciennes. I am unable to ascertain at present if these names have been published or not.

Corrigenda in Contributions to Indian Malacology, No. VI., in this volume:

P. 31,	line	2,	from	bottom,	for	Kimery	read Kimety.
32,	,,	7,	,,	top,	,,	*Fordoni*	,, *Gordoni.*
,,	,,	8,	,,	bottom,	,,	Hattiwar	,, Kattiawar.
34,	,,	2,	,,	,,	,,	inwardly	,, conoidly.
35,	,,	15,	,,	top,	,,	*subgesta*	,, *subjecta.*
37,	,,	12,	,,	bottom,		supply "it"	after nulla.
,,	,,	9,	,,	,,		omit the word South.	
38,	,,	10,	,,	top,	,,	oblong ovate, Achatina	read oblong ovate Achatinæ.
,,	,,	17,	,,	,,	,,	*Basilens*	,, *Basileus.*
,,	,,	12,	,,	bottom,	,,	*Algeæus*	,, *Algeæus.*
,,	,,	8,	,,	,,	,,	Recleiz	,, Recluz.
39,	lines	21, 16 & 11,	from	bottom,	for	*Basilens*	,, *Basileus.*
,,	line	17,	from	bottom,	for	Wynand	,, Wynaud.
,,	,,	14,	,,	,,	,,	Paulghat cherry	,, Paulghatcherry
,,	,,	5,	,,	,,	,,	of that *N. auris*	,, of *N. auris.*
,,	,,	2,	,,	,,	,,	base by	,, barely.
41,	,,	11,	,,	top,	,,	slighly	,, slightly.

In the previous number V. of the Contributions, an important error occurs N. CONULA, n. s. for N. CONULUS (J. A. S. B. XXXIV, 73, 1865).

In the same page, Phoung ditto, Arakan, should be Phoung Do, and three pages further, p. 76, line 12, a semicolon is omitted, altering the sense. The passage should read "a vertical lamina in front, and a second, slightly oblique, just behind; the first giving out" &c. instead of "just behind the first." The only other erratum of importance is in page 81, line 20, where "re-entering lamellar parietal" should be "re-entering parietal lamella."

SCIENTIFIC INTELLIGENCE.

The following is from Mr. Blyth :—

I have already elucidated* sundry species of Ægialites (or Ring Plover) and may now further add that I have since made out the *Charadrius pusillus* of Horsfield to be the same as *Æ. ruficapillus*, Gould, figured in his Birds of Australia : Horsfield's specimen being in winter dress, and his name of course standing for the species.

The Indian Neophron (281) will have to rank as *N. ginginianus*, Latham. The *Spilornis* of Ceylon and of all S. India is the same as *S. Elgini*, Tytler, and will bear my prior name *Spilogaster* (J. A. S. XXI. 351) being distinct from the Malayan *S. bacha*, with which Professor Schlegel identifies it. *Falco babylonicus* is the *F. peregrinoides* apud G. R. Gray, as suggested in p. 282. The Cat noticed as *Felis macrocelis* in p. 283 seems, after all, to be of a different and smaller race than one received from Asám also in the Zoological Gardens. It has now been more than three years in the garden, and has only a slight fulvous tendency even yet, while the other is much more fulvescent, and is also of heavier build. I think that the larger only has the very elongated canine teeth. Neither seems to be the true *Diardii* (vel *macrocelis*) of Sumatra and Borneo; and I suspect that the larger and more fulvous animal (which the Society's Museum has from Sikhim) should rank as *F. nebulosa*, C. H. Smith, figured in Griffith's English edition of the *Règne animal*. There is also great variation in the *F. aurata*, Tem. (*murmensis*, Hodgson, and the young *F. Temminckii*, Vigors.) A rufous specimen in the India Museum has strongly developed body-markings, akin in type to those of the *macrocelis* group ; others (alike from Sikhim, Malacca and Sumatra,) are deep rufous without trace of body-markings; and thirdly, there is the blackish race, which is designated *F. nigrescens*, Hodgson, in the second edition of the British Museum Catalogue of Mr. Hodgson's collections. These Cats would seem, in fact, to be in process of specialization, which is carried on a further stage in the *F. Swinhoei* of Formosa, as compared with the other races akin to *F. Diardii*. Lastly, *F. Charltoni* may be a race not strongly specialized apart from *F. marmorata*.

* Asiatic Society's Journal, vol. XXXIV. p. 280.

The whole of these constitute a group of E. and S. E. Asiatic Cats *per se*, which have not the peculiar clubbed tail of *F. uncia*, with which Dr. Gray associates them. To the species of birds to be expunged from Jerdon's Indian series (p. 282), may be added *Otocoris penicillata*, for which *O. longirostris* of Kashmir, Kooloo, &c., has hitherto been mistaken. *O. penicillata* of W. Asia is smaller, with much longer ear-tufts, and the black of the cheeks is continuous with that of the breast. Have I told you that *Carpophaga cuprea*, Jerdon, is well distinguished from *C. insignis*, Hodgson, having the neck and lower parts much more ashy, while both differ from *C. badia*, (Raffles), of Sumatra? Of *C. pusilla*, nobis, I have seen more specimens from S. India, where perhaps it co-exists with the large *C. ænea;* and both *cuprea* and *pusilla* are very likely to inhabit the mountains of Ceylon. *Graucalus Layardi*, nobis, (*papuensis* apud Sykes,) of S. India and Ceylon, is very distinct from *G. macei* of Bengal, &c., much smaller, with the wings strongly banded underneath. The Malayan *G. javensis* is a miniature of *G. macei*, of the same small size as *G. Layardi*. As many as four races have been confounded under *Pycnonotus jocosus*, (L.,) a name which must be retained for that of China, which I have not seen. The Bengal bird will stand as *emeria* of Shaw (*pyrrhotis*, Hodgson). The Tenasserim and Penang race is *monticolus*, M'Clelland. That of S. India will be named by Gould, and it has no white markings on the rectrices. In the Zoological Gardens are apparently two new species of Pheasant. One is a female, of a duplicate race to *nycthemerus*, being of the true silver Pheasant type. The other is a male; very like *lineatus* of Burma; but the markings of the upper parts more resemble those of *nycthemerus;* it has no white along the ridge of the tail, and no white streaks on the flanks. Some think it a hybrid; but, if so, it can only be between *lineatus* and *nycthemerus*. The tail, however, is shaped exactly as in the former, whereas it should be considerably more lengthened, if the bird had *nycthemerus* for one parent; and its legs also should in that case be larger, and shew some trace of the crimson colour of those of *nycthemerus*. I am, therefore, disposed to consider it as a true wild race of Kallij, probably from some more eastern part of the Indo-Chinese peninsula.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of September, 1865.

Latitude 22° 33′ 1″ North. Longitude 88° 20′ 34″ East.

Height of the Cistern of the Standard Barometer above the Sea-level, 18 ft. 11 in.

Daily Means, &c. of the Observations and of the Hygrometrical elements dependent thereon.

Date.	Mean Height of the Barometer at 32° Faht.	Range of the Barometer during the day.			Mean Dry Bulb Thermometer.	Range of the Temperature during the day.		
		Max.	Min.	Diff.		Max.	Min.	Diff.
	Inches.	Inches.	Inches.	Inches.	o	o	o	o
1	29.645	29.705	29.596	0.109	85.2	87.7	83.4	4.3
2	.680	.727	.625	.102	83.9	88.8	79.2	9.6
3	.663	.725	.584	.141	84.5	89.8	81.0	8.8
4	.629	.692	.551	.141	84.4	89.4	81.8	7.6
5	.599	.665	.527	.138	85.2	89.8	81.4	8.4
6	.620	.701	.566	.135	84.5	88.0	82.2	5.8
7	.673	.728	.604	.124	85.4	91.8	82.4	9.4
8	.639	.696	.553	.143	82.3	84.8	80.4	4.4
9	580	.638	.513	.125	81.3	83.8	79.6	4.2
10	.580	.620	.519	.101	81.5	85.0	80.2	4.8
11	.570	.629	.514	.115	81.7	86.4	79.6	6.8
12	.601	.667	.545	.122	81.0	86.6	78.2	8.4
13	.669	.745	.614	.131	78.5	81.2	76.8	4.4
14	.756	.809	.701	.108	79.3	84.6	75.4	9.2
15	.770	.833	.694	.139	83.4	88.6	78.6	10.0
16	.733	.806	.634	.172	85.2	90.3	80.4	9.9
17	.702	.772	.619	.153	86.7	91.4	81.8	9.6
18	.689	.759	.584	.175	87.1	93.0	82.2	10.8
19	.686	.751	.603	.148	86.6	92.8	82.4	10.4
20	.656	.713	.584	.129	83.8	89.0	79.0	10.0
21	.624	.670	.549	.121	85.2	90.4	81.1	9.3
22	.645	.696	.604	.092	85 4	90.2	80.8	9.4
23	.673	.727	.630	.097	85.5	89.6	82.2	7.4
24	.723	.789	.676	.113	84 0	89 6	79.2	10.4
25	.784	.838	.727	.111	84.9	91.2	79.2	12.0
26	.800	.855	.732	.123	85.8	91.6	81.9	9.7
27	.761	.832	.689	.143	86.1	90.7	82.2	8.5
28	.707	.784	.638	.146	85.8	90.4	82.2	8.2
29	.696	.754	.635	.119	85.3	90.6	83.4	7.2
30	.718	.780	.660	.120	86.6	91.8	83.2	8.6

The Mean Height of the Barometer, as likewise the Dry and Wet Bulb Ther- ... the hourly Observations made during the day.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of September, 1865.

Daily Means, &c. of the Observations and of the Hygrometrical elements dependent thereon.—*(Continued.)*

Date.	Mean Wet Bulb Thermometer.	Dry Bulb above Wet.	Computed Dew Point.	Dry Bulb above Dew Point.	Mean Elastic force of Vapour.	Mean Weight of Vapour in a Cubic foot of air.	Additional Weight of Vapour required for complete saturation.	Mean degree of Humidity, complete saturation being unity.
	o	o	o	o	Inches.	T. gr.	T. gr.	
1	82.3	2.9	80.3	4.9	1.011	10.80	1.81	0.86
2	81.4	2.5	79.6	4.3	0.989	.60	.53	.87
3	81.5	3.0	79.4	5.1	.983	.51	.84	.85
4	81.9	2.5	80.1	4.3	1.005	.75	.56	.87
5	81.8	3.4	79.4	5.8	0.983	.49	2.12	.83
6	82.2	2.3	80.6	3.9	1.021	.92	1.43	.88
7	82.4	3.0	80.3	5.1	.011	.80	.88	.85
8	80.9	1.4	79.9	2.4	0.998	.74	0.84	.93
9	79.7	1.6	78.6	2.7	.958	.32	.92	.92
10	79 7	1.8	78.4	3.1	.952	.25	1.06	.91
11	79.8	1 9	78.5	3.2	.955	.29	.08	.91
12	79.1	1.9	77.8	3.2	.934	.07	.07	.90
13	77.5	1.0	76.8	1.7	.905	9.79	0.56	.95
14	77 9	1.4	76.9	2.4	.908	.82	.77	.93
15	80.4	3.0	78.3	5.1	.949	10.18	1.78	.85
16	81.5	3.7	78.9	6.3	.967	.34	2 27	.82
17	82.2	4.5	79.5	7.2	.986	.51	.67	.80
18	82.4	4.7	79.6	7.5	.989	.52	.81	.79
19	81.8	4 8	78.9	7.7	.967	.30	.84	.78
20	80.5	3.3	78.2	5.6	.946	.13	1.97	.84
21	81.3	3.9	78.6	6 6	.958	.23	2.38	.81
22	79.6	5.8	75.5	9.9	.868	9.27	3.41	.73
23	80.0	5.5	76.1	9.4	.885	.46	.26	.74
24	79.2	4.8	75.8	8.2	.876	.39	2.78	.77
25	80.6	4.3	77.6	7.3	.928	.93	.56	.80
26	81.3	4.5	78.1	7.7	.943	10.06	.77	.78
27	80.2	5.9	76.1	10.0	.885	9.44	3.51	.73
28	80.4	5.4	76.6	9.2	.899	.59	.24	.75
29	80.8	4.5	77.6	7.7	.928	.91	2.73	.78
30	80.9	5.7	77.5	9.1	.925	.86	3.28	.75

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of September, 1865.

Hourly Means, &c. of the Observations and of the Hygrometrical elements dependent thereon.

Hour.	Mean Height of the Barometer at 32° Faht.	Range of the Barometer for each hour during the month.			Mean Dry Bulb Thermometer.	Range of the Temperature for each hour during the month.		
		Max.	Min.	Diff.		Max.	Min.	Diff.
	Inches.	Inches.	Inches.	Inches.	o	o	o	o
Mid-night.	29.693	29.815	29.599	0.216	82.5	84.6	78.0	6.6
1	.683	.811	.584	.227	82.3	84.2	78.0	6.2
2	.670	.796	.563	.233	82.2	84.0	78.4	5.6
3	.661	.786	.553	.233	82.0	84.2	78.6	5.6
4	.657	.792	.547	.245	81.7	84.4	78.0	6.4
5	.665	.798	.549	.249	81.5	84.5	77.5	7.0
6	.678	.812	.554	.258	81.2	84.6	75.6	9.0
7	.694	.832	.569	.263	82.0	85.2	75.4	9.8
8	.714	.851	.587	.264	83.4	86.8	75.5	11.3
9	.726	.850	.598	.252	84.7	88.1	75.4	12.7
10	.727	.855	.594	.261	85.7	89.8	76.1	13.7
11	.713	.854	.586	.268	86.7	91.2	76.9	14.3
Noon.	.691	.835	.567	.268	87.4	92.0	78.4	13.6
1	.669	.807	.547	.260	87.5	92.8	80.5	12.3
2	.645	.775	.528	.247	87.5	93.0	79.6	13.4
3	.622	.748	.523	.225	87.4	92.0	79.5	12.5
4	.614	.735	.513	.222	87.0	91.6	79.6	12.0
5	.618	.732	.514	.218	86.6	91.4	79.2	12.2
6	.633	.744	.539	.205	85.3	89.4	76.8	12.6
7	.655	.767	.559	.208	84.5	88.2	77.4	10.8
8	.678	.796	.574	.222	83.6	87.4	77.4	10.0
9	.697	.806	.588	.218	83.1	86.0	77.8	8.2
10	.707	.808	.601	.207	82.8	85.4	77.8	7.6
11	.704	.810	.611	.199	82.5	84.8	78.1	6.7

The Mean Height of the Barometer, as likewise the Dry and Wet Bulb Thermometer Means are derived from the Observations made at the several hours during the month.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of September, 1865.

Hourly Means, &c. of the Observations and of the Hygrometrical elements dependent thereon.—*(Continued.)*

Hour.	Mean Wet Bulb Thermometer.	Dry Bulb above Wet.	Computed Dew Point.	Dry Bulb above Dew Point.	Mean Elastic force of Vapour.	Mean Weight of Vapour in a Cubic foot of air.	Additional Weight of Vapour required for complete saturation.	Mean degree of Humidity, complete saturation being unity.
	o	o	o	o	Inches.	Troy grs.	Troy grs.	
Mid-night.	80.7	1.8	79.4	3.1	0.983	10.56	1.08	0.91
1	80.6	1.7	79.4	2.9	.983	.56	.02	.91
2	80.5	1.7	79.3	2.9	.979	.53	.01	.91
3	80.3	1.7	79.1	2.9	.973	.47	.00	.91
4	80.2	1.5	79.1	2.6	.973	.47	0.90	.92
5	80.0	1.5	78.9	2.6	.967	.41	.90	.92
6	79.8	1.4	78.8	2.4	.964	.40	.81	.93
7	80.3	1.7	79.1	2.9	.973	.47	1.00	.91
8	80.4	3.0	78.3	5.1	.949	.18	.78	.85
9	80.7	4.0	77.9	6.8	.937	.02	2.40	.81
10	80.9	4.8	77.5	8.2	.925	9.88	.92	.77
11	81.3	5.4	78.1	8.6	.943	10.04	3.14	.76
Noon.	81.3	6.1	77.6	9.8	.928	9.87	.58	.73
1	81.1	6.4	77.3	10.2	.919	.78	.71	.73
2	81.0	6.5	77.1	10.4	.913	.72	.77	.72
3	80 9	6 5	77.0	10.4	910	.69	.76	.72
4	80.9	6.1	77.2	9.8	.916	.75	.54	.73
5	81.1	5.5	77.8	8.8	.934	.95	.19	.76
6	81.2	4.1	78 3	7.0	.949	10.14	2.50	.80
7	81 1	3.4	78.7	5.8	.961	.29	.06	.83
8	80.9	2.7	79.0	4.6	.970	.40	1.63	.87
9	80.7	2.4	79.0	4.1	.970	.42	.44	.88
10	80.5	2 3	78.9	3.9	.967	.39	.36	.88
11	80.5	2.0	79.1	3.4	.973	.47	.17	.90

All the Hygrometrical elements are computed by the Greenwich Constants.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of September, 1865.

Solar Radiation, Weather, &c.

Date.	Max. Solar radiation.	Rain Gauge 5 feet above Ground.	Prevailing direction of the Wind.	General Aspect of the Sky.
	o	Inches.		
1	...	...	S.	Overcast.
2	137.0	1.76	S. & W.	Overcast nearly the whole day. Rain from 3 to 7 A. M. & from noon to 2 P. M. Thunder towards N. at 9 P. M.
3	138.0	...	W. & S. & S. W.	\⌒i & \i to 7 A. M. ⌒i to 5 P. M. Overcast afterwards. Thin rain at 10 & 11 A. M. & 6 P. M. Thunder towards N. W. at 7 P. M. Lightning towards N. from 7 to 9 P. M.
4	...	...	S. W. & S. E.	⌒i to 6 A. M. Overcast to 11 A. M. ⌒i & \⌒i afterwards. Thin rain at 10 & 11 A. M.
5	133.0	...	E.	\⌒—i to 5 A. M. ⌒—i to 3 P. M. Clouds of different kinds afterwards. Light rain between 7 & 8 P. M.
6	...	0.76	N.	\—i & ⌒—i to 7 A. M. ⌒i to 3 P. M. Overcast afterwards. Rain at 5 A. M. & 4 P. M.
7	142.0	...	N.	⌒i to 2 P. M. Overcast afterwards. Thin rain between midnight & 1 A. M. & at 4 & 7 P. M.
8	...	0.21	N.	Overcast. Scud. from N. at 6 & 7 A. M. Thin rain from 9 A. M. to 9 P. M.
9	...	0.42	E. & N. E.	Overcast nearly the whole day. Light rain after intervals.
10	...	...	E. & S. E. & N. E.	Overcast to 7 P. M. Cloudless afterwards. Thin rain at 7 A. M. & from 10 to 1 P. M. & at 4 P. M.
11	...	0.78	E. & N. E. & N.	Overcast nearly the whole day. Rain from 3 to 8 A. M. & from 1 to 3 P. M.
12	123.5	0.12	N. E. & E.	Overcast. Scud. from E. from 8 to noon. Thin rain after intervals.
13	...	2.36	E. & S. E.	Overcast. Scud. from S. E. from 6 to 10 P. M. Rain from 4 A. M. to 11 P. M.
14	...	1.11	E. & S. E.	Overcast to 5 P. M. Scatd. \—i afterwards. Rain from 5 to 11 A. M. & between 4 & 5 P. M.
15	124.0	...	E. & S.	Overcast to 8 A. M. ⌒i to 6 P. M. Clear afterwards. Thin rain between 3 & 4 P. M.
16	132.8	...	S. & N. E.	Clear to 7 A. M. ⌒i to 6 P. M. Clear afterwards. Lightning towards S. E. at 7 P. M.

\i Cirri, —i Strati, ⌒i Cumuli, \—i Cirro-strati, ⌒—i Cumulo-strati, \⌒—i Nimbi, \⌒i Cirro-cumuli.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of September, 1865.

Solar Radiation, Weather, &c.

Date.	Max. Solar radiation.	Rain Gauge 5 feet above Ground.	Prevailing direction of the Wind.	General Aspect of the Sky.
	o	Inches		
17	137.4	...	S. & E.	Clear to 7 A. M. ⌒i afterwards. *Lightning* & Thunder at 8 & 9 P. M. Light rain between 8 & 9 P. M.
18	144.0	...	S. & E.	Clear to 5 A. M. ⌒i afterwards. Lightning towards N. W. at 7, 8 & 9 P. M.
19	143.9	0.47	S. & E.	Clear to 4 A. M. ╲i to 7 A. M. ⌒i to 6 P. M. Overcast afterwards. Lightning from Midnight to 3 A. M. & at 7 P. M. Rain at 8 & 9 P. M.
20	137.0	0.58	N. W. & variable.	Clear to 5 A. M. Clouds of different kinds afterwards. Rain & Thunder at 1, 2 & 3 P. M. Lightning at 7 P. M.
21	141.8	0.11	N. W. & N.	Clear to 8 A. M. ⌒i to 6 P. M. Clear afterwards. Rain between 3 & 4 P. M.
22	144.0	...	N. & N. W.	Clear to 9 A. M. ⌒i & ╲_i to 7 P. M. Clear afterwards.
23	130.0	...	N. W. & W. & N.	Clear to 5 A. M. ╲i to 10 A. M. ╲⌒i to 5 P. M. ╲_i afterwards.
24	140.4	0.41	W.	Overcast to 10 A. M. ⌒i afterwards. Rain at 2, 3-10 & 11 P. M.
25	141.8	1.16	S. & E.	╲_i to 4 A. M. ╲⌒i to 4 P. M. clear afterwards. Thunder & lightning towards S. W. at 3 A. M. rain from 2 to 4 A. M.
26	142.0	...	S. & S. W. & E.	Clear to 5 A. M. ╲⌒i to 2 P. M. ╲i to 6 P. M. clear afterwards.
27	140.0	...	W. & N. W.	Clear nearly the whole day.
28	135.4	...	W.	╲i to 7 A. M. ⌒i afterwards.
29	130.0	...	N. & W.	╲_i to 3 A. M. ⌒i to 3 P. M. ╲_i afterwards. Thin rain at 4 P. M.
30	139.4	...	N.	Overcast to 5 A. M. ⌒i to 5 P. M. clear afterwards.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of September, 1865.

Monthly Results.

	Inches
Mean height of the Barometer for the month, ...	29.676
Max. height of the Barometer occurred at 10 A. M. on the 26th, ..	29.855
Min. height of the Barometer occurred at 4 P. M. on the 9th, ..	29.513
Extreme range of the Barometer during the month, ...	0.342
Mean of the Daily Max. Pressures, ...	29.737
Ditto ditto Min. ditto, ...	29.609
Mean daily range of the Barometer during the month, ...	0.128

	o
Mean Dry Bulb Thermometer for the month, ...	84.2
Max. Temperature occurred at 2 P. M. on the 18th, ...	93.0
Min. Temperature occurred at 7 A. M. on the 14th, ...	75.4
Extreme range of the Temperature during the month, ...	17.6
Mean of the daily Max. Temperature, ...	89.0
Ditto ditto Min. ditto, ...	80.7
Mean daily range of the Temperature during the month, ...	8.3

Mean Wet Bulb Thermometer for the month, ...	80.7
Mean Dry Bulb Thermometer above Mean Wet Bulb Thermometer, ..	3.5
Computed Mean Dew-point for the month, ...	78.2
Mean Dry Bulb Thermometer above computed Mean Dew-point, ..	6.0
	Inches
Mean Elastic force of Vapour for the month, ...	0.946

	Troy grains
Mean Weight of Vapour for the month, ...	10.13
Additional Weight of Vapour required for complete saturation, ..	2.11
Mean degree of humidity for the month, complete saturation being unity,	0.83

	Inches
Rained 21 days, Max. fall of rain during 24 hours, ...	2.36
Total amount of rain during the month, ...	10.25
Prevailing direction of the Wind, ...	E. & N. & S.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of September, 1865.

Monthly Results.

Tables showing the number of days on which at a given hour any particular wind blew, together with the number of days on which at the same hour, when any particular wind was blowing, it rained.

Hour.	N.	Rain on.	N. E.	Rain on.	E.	Rain on.	S. E.	Rain on.	S.	Rain on.	S. W.	Rain on.	W.	Rain on.	N. W.	Rain on.	Calm.	Rain on.	Missed.
									No. of days.										
Midnight.	3		4		6		3		8		1		4		1				
1	3		4		5		3	1	7		1		4		2				1
2	5		3		5		2		6		1		5		3	1			
3	6	1	4	1	4		2		6	1	2	1	4		2				
4	7	1	2	1	7	2			6	1	1		5	1	2				
5	6	2	2		7	2			6		1		5	1	3				
6	5	1	2	1	5	1	2	1	6		1		5	1	4				
7	5		3	2	6	3	1		5		1		5	1	4				
8	6		6	2	4	1	2	1	1		2		6		3				
9	7	1	7	1	3		2	2	3		1		5		2				
10	7	1	4		7	2	2	2	2				5	2	3				
11	5	1	5		7	2	2	2	2	1	2		2	1	5				
Noon.	2		3		8	1	4	1	1		2		4		6	1			
1	5		3	1	8	3	2	2	4	2	2		4		2				
2	5	1	3		5	3	3		4	1	1	1	4	1	5				
3	3	1	2	1	5		4	1	6	1	1	1	3		6				
4	8	5	1		6	2	4		6	2	1		4						
5	7	1	1		6		3	1	6	1	3		3		1				
6	7	1	1		7	1	3	1	5	1	2		4		1				
7	8	2	1		6	1	2		5		3		4		1				
8	7	1			8	2	3	1	5		2		4		1				
9	5		1	1	9	2	3		6	1	1		4		1				
10	3		1		10	2	2		7		2	1	4		1				
11	3		4		6	1	2		8		2	1	4		1				

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of October, 1865.

Latitude 22° 33′ 1″ North. Longitude 88° 20′ 34″ East.

Height of the Cistern of the Standard Barometer above the Sea-level, 18 ft. 11 in.

Daily Means, &c. of the Observations and of the Hygrometrical elements dependent thereon.

Date.	Mean Height of the Barometer at 32° Faht.	Range of the Barometer during the day.			Mean Dry Bulb Thermometer.	Range of the Temperature during the day.		
		Max.	Min.	Diff.		Max.	Min.	Diff.
	Inches.	Inches.	Inches.	Inches.	o	o	o	o
1	29.727	29.796	29.656	0.140	87.2	92 2	83.3	8.9
2	.718	.777	.640	.137	86.7	92.2	81.2	11.0
3	.763	.831	.716	.115	87.4	93 2	82.2	11.0
4	.753	.824	.692	.132	87.2	93.1	81.3	11.8
5	.751	.812	.692	.120	87.2	92.8	82.2	10.6
6	.751	.807	.687	.120	87.4	93.0	82.5	10.5
7	.788	.842	.736	.106	86.9	92.6	81.2	11.4
8	.855	.912	.801	.111	87.1	92.8	82.6	10.2
9	.864	.931	.788	.143	86.8	93.4	82.0	11.4
10	.873	.944	.823	.121	85.8	92.1	81.4	10.7
11	.882	.951	.815	.136	85.9	91.8	81.6	10.2
12	.884	.951	.821	.130	84.7	91.2	79.8	11.4
13	.890	.962	.839	.123	83.4	90.8	78.2	12.6
14	.914	.999	.863	.136	85.3	92.2	80.0	12.2
15	.922	30.005	.854	.151	84.8	92.6	79 0	13.6
16	.887	29.953	.824	.129	84 4	91.4	78.5	12.9
17	.859	.929	.807	.122	83.8	90.2	77.4	12.8
18	.855	.915	.794	.121	83.6	89.8	77.4	12.4
19	.876	.943	.777	.166	84.3	90.0	79.0	11 0
20	.918	.987	.867	.120	83.8	90.0	78.0	12.0
21	.904	.969	.846	.123	83.0	87.6	79.8	7.8
22	.853	.922	.799	.123	83.8	90.6	78.9	11.7
23	.842	.915	.808	.107	84.0	91.4	79.0	12.4
24	.847	.917	.807	.110	81.3	89.0	74.8	14.2
25	.856	.935	.815	.120	80.5	89.6	72.6	17.0
26	.857	.933	.804	.129	81.0	89.8	72.8	17.0
27	.839	.904	.786	.118	81.9	90.2	74.0	16.2
28	.873	.935	.830	.105	82.9	91.4	76.6	14.8
29	.918	.998	.863	.135	82.4	89.6	76.2	13.4
30	.904	.983	.838	.145	81.5	88.8	75.6	13.2
31	.875	.952	.807	.145	79.5	86.6	73.4	13.2

The Mean Height of the Barometer, as likewise the Dry and Wet Bulb Thermometer Means are derived from the hourly Observations made during the day.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of October, 1865.

Daily Means, &c. of the Observations and of the Hygrometrical elements dependent thereon.—*(Continued.)*

Date.	Mean Wet Bulb Thermometer.	Dry Bulb above Wet.	Computed Dew Point.	Dry Bulb above Dew Point.	Mean Elastic force of Vapour.	Mean Weight of Vapour in a Cubic foot of air.	Additional Weight of Vapour required for complete saturation.	Mean degree of Humidity, complete saturation being unity.
	o	o	o	o	Inches.	T. gr.	T. gr.	
1	81 2	6.0	77.6	9.6	0.928	9.87	3.50	0.74
2	79.9	6.8	75.8	10.9	.876	.33	.85	.71
3	80.0	7.4	75.6	11.8	.871	.25	4.20	.69
4	80.0	7.2	75.7	11.5	.873	.28	.09	.69
5	79.8	7.4	75.4	11.8	.865	.20	.17	.69
6	79.9	7.5	75.4	12.0	.865	.20	.25	.68
7	79.9	7.0	75.7	11.2	.873	.30	3.95	.70
8	79.9	7.2	75.6	11.5	.871	.25	4.08	.69
9	80.9	5.9	77.4	9.4	.922	.83	3.38	.74
10	80.6	5.2	77.0	8.8	.910	.71	.12	.76
11	80.1	5.8	76.0	9.9	.882	.41	.46	.73
12	79.6	5.1	76.0	8.7	.882	.43	2.99	.76
13	78.8	4.6	75.6	7.8	.871	.33	.63	.78
14	79.1	6.2	74.8	10.5	.849	.06	3.58	.72
15	76.9	7.9	71.4	13.4	.761	8.13	4.33	.65
16	76.7	7.7	71.3	13.1	.758	.11	.20	.66
17	76.3	7.5	71.0	12.8	.751	.04	.06	.66
18	76.3	7.3	71.2	12.4	.756	.10	3.93	.67
19	76.7	7.6	71.4	12.9	.761	.13	4.15	.66
20	77.7	6.1	73.4	10.4	.811	.69	3.41	.72
21	78.7	4.3	75.7	7.3	.873	9.38	2.44	.79
22	78.6	5.2	75.0	8.8	.854	.14	.96	.76
23	75.7	8.3	69.9	14.1	.725	7.76	4.41	.64
24	71.5	9.8	64.6	16.7	.609	6.55	.69	.58
25	70.7	9.8	63.8	16.7	.593	.39	.59	.58
26	71.8	9.2	65.4	15.6	.626	.73	.41	.60
27	73.9	8.0	68.3	13 6	.688	7.39	.05	.65
28	76.1	6.8	71.3	11.6	.758	8.13	3.66	.69
29	76.2	6.2	71.9	10.5	.773	.29	.32	.71
30	74.3	7.2	69.3	12.2	.711	7.64	.67	.68
31	72.1	7.4	66.9	12.6	.657	.09	.57	.67

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of October, 1865.

Hourly Means, &c. of the Observations and of the Hygrometrical elements dependent thereon.

Hour.	Mean Height of the Barometer at 32° Faht.	Range of the Barometer for each hour during the month.			Mean Dry Bulb Thermometer.	Range of the Temperature for each hour during the month.		
		Max.	Min.	Diff.		Max.	Min.	Diff.
	Inches.	Inches.	Inches.	Inches.	o	o	o	o
Mid-night.	29.847	29.923	29.732	0.191	81.1	85.0	76.4	8.6
1	.839	.918	.719	.199	80.7	84.3	76.0	8.3
2	.832	.908	.709	.199	80.3	84.0	75.2	8.8
3	.828	.903	.706	.197	80.0	83.6	74.4	9.2
4	.831	.914	.708	.206	79.6	83.4	73.6	9.8
5	.844	.931	.722	.209	79.2	83.3	72.8	10.5
6	.861	.949	.738	.211	79.0	83.5	72.6	10.9
7	.882	.974	.754	.220	80.2	85.0	73.8	11.2
8	.901	.997	.773	.224	82.8	86.4	77.4	9.0
9	.915	30.004	.777	.227	84.8	88.2	79.8	8.4
10	.914	.005	.766	.239	86.7	90.0	83.0	7.0
11	.897	29.988	.747	.241	88.3	90.8	83.6	7.2
Noon.	.871	.975	.716	.259	89.4	92.0	86.6	5.4
1	.840	.919	.695	.224	90.0	92.8	85.2	7.6
2	.813	.889	.664	.225	90.4	93.0	85.3	7.7
3	.798	.871	.648	.223	90.8	93.2	85.0	8.2
4	.791	.863	.640	.223	90.2	92.8	84.4	8.4
5	.798	.873	.649	.224	89.8	93.4	83.1	10.3
6	.807	.879	.671	.208	86.5	89.6	81.6	8.0
7	.824	.894	.690	.204	84.8	88.4	80.2	8.2
8	.846	.920	.712	.208	83.8	87.2	78.8	8.4
9	.857	.930	.727	.203	82.9	86.6	78.0	8.6
10	.863	.932	.733	.199	82.1	86.0	77.0	9.0
11	.857	.934	.734	.200	81.4	85.6	76.2	9.4

The Mean Height of the Barometer, as likewise the Dry and Wet Bulb Thermometer Means are derived from the Observations made at the several hours during the month.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of October, 1865.

Hourly Means, &c. of the Observations and of the Hygrometrical elements dependent thereon.—*(Continued.)*

Hour.	Mean Wet Bulb Thermometer.	Dry Bulb above Wet.	Computed Dew Point.	Dry Bulb above Dew Point.	Mean Elastic force of Vapour.	Mean Weight of Vapour in a Cubic foot of air.	Additional Weight of Vapour required for complete saturation.	Mean degree of Humidity, complete saturation being unity.
	o	o	o	o	Inches.	Troy grs.	Troy grs.	
Mid-night.	77.7	3.4	75.3	5.8	0.862	9.29	1.88	0.83
1	77.6	3.1	75.4	5.3	.865	.34	.70	.85
2	77.4	2.9	75.4	4.9	.865	.34	.57	.86
3	77.2	2.8	75.2	4.8	.860	.28	.53	.86
4	77.0	2.6	75.2	4.4	.860	.30	.39	.87
5	76.7	2.5	74.9	4.3	.851	.21	.35	.87
6	76.5	2.5	74.7	4.3	.846	.16	.34	.87
7	76.9	3.3	74.6	5.6	.843	.09	.79	.84
8	77.1	5.7	73.1	9.7	.803	8.61	3.14	.73
9	77.2	7.6	71.9	12.9	.773	.26	4.20	.66
10	77.5	9.2	72.0	14.7	.776	.25	.93	.63
11	77.6	10.7	71.2	17.1	.756	.02	5.78	.58
Noon.	77.5	11.9	70.4	19.0	.736	7.79	6.46	.55
1	77.3	12.7	69.7	20.3	.720	.61	.89	.53
2	77.2	13.2	69.3	21.1	.711	.50	7.17	.51
3	77.0	13.8	68.7	22.1	.697	.35	.49	.50
4	77.1	13 1	69.2	21.0	.708	.48	.11	.51
5	77.7	12.1	70.4	19.4	.736	.79	6.63	.54
6	78.1	8.4	73.1	13.4	.803	8.56	4.54	.65
7	78.8	6.5	73.7	11.1	.819	.76	3.70	.70
8	78.2	5.6	74.3	9.5	.835	.94	.16	.74
9	78.0	4.9	74.6	8.3	.843	9.05	2.74	.77
10	77.7	4.4	74.6	7.5	.843	.05	.46	.79
11	77.7	3.7	75.1	6.3	.857	.23	.04	.82

All the Hygrometrical elements are computed by the Greenwich Constants.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of October, 1865.

Solar Radiation, Weather, &c.

Date.	Max. Solar radiation.	Rain Gauge 5 feet above Ground.	Prevailing direction of the Wind.	General Aspect of the Sky.
	o	Inches.		
1	142.2	...	N. W. & S.	Clear.
2	139.4	...	N. W.	Clear.
3	140.0	...	W. & N. W.	Clear.
4	140.0	...	W.	Clear to noon, Scatd. ⌒i to 5 P. M., clear afterwards.
5	144.5	...	W. & N.	Clear.
6	138.0	...	N. W. & N. & W.	Clear.
7	139.9	...	W. & N. W.	Clear to 7 A. M. \i to the E. to 3 P. M., clear afterwards.
8	139.7	...	W.	Clear.
9	138.0	...	W. & S.	Clear to 11 A. M. ⌒i to 5 P. M. clear afterwards.
10	139.0	...	S. & S. W.	\—i to 5 A. M. \⌒i to noon, clouds of various kinds afterwards.
11	142.0	...	S. & S. W.	Clear to 11 A. M. ⌒i round the horizon to 6 P. M., clear to 9 P. M. \⌒—i to the N. afterwards.
12	138.6	...	S. & S. W. & E.	\⌒i to 11 A. M. ⌒i to 5 P. M. \⌒—i to the S. W. afterwards.
13	139.0	...	S. & S. W. & S. E.	Clear to 4 A. M. Overcast to 11 A. M. ⌒i to 6 P. M. \⌒—i to the W. afterwards.
14	142.0	...	E. & W. & S. W.	\—i to 10 A. M. ⌒i to 5 P. M., clear afterwards.
15	149.4	...	W. & S.	Clear to noon, ⌒i to 4 P. M., clear afterwards.
16	139.8	...	N. W.	Clear to 10 A. M. ⌒i to 4 P. M., clear afterwards.
17	142.0	...	N. & N. W.	Clear to 9 A. M. ⌒i to 5 P. M. clear afterwards.
18	142.6	...	N. & N. W.	Clear to 9 A. M. ⌒i to 6 P. M. \⌒—i to the E. afterwards.
19	143.0	...	N. & W. & N. W.	\—i to 3 A. M. clear to 10 A. M. Scatd. ⌒i afterwards.
20	144.4	...	S. & E.	Clear to 9 A. M. Scatd. ⌒i to 5 P. M., clear afterwards.
21	133.6	...	S. E.	Clear to 5 A. M. \⌒i to 7 P. M., clear afterwards.
22	139.0	...	W. & S. E.	Clear to 7 A. M. Scatd. ⌒i to 4 P. M., clear afterwards.

\i Cirri, —i Strati, ⌒i Cumuli, \—i Cirro-strati, ⌒—i Cumulo-strati, \⌒—i Nimbi, \⌒i Cirro-cumuli.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of October, 1865.

Solar Radiation, Weather, &c.

Date.	Max. Solar radiation.	Rain Gauge 5 feet above Ground.	Prevailing direction of the Wind.	General Aspect of the Sky.
	o	Inches		
23	143.8	...	W. & S.	\⌒-i to the E. & N. W. to 4 A. M. _i to 8 A. M., clear afterwards.
24	141.0	...	W. & S. W.	Clear.
25	140.0	...	W. & S. W.	Clear.
26	142.4	...	W.	Clear.
27	137.5	...	S. W.	Clear.
28	145.0	...	S. W. & W.	Clear to 4 A. M. \⌒i to 5 P. M., clear afterwards.
29	144.0	...	E.	Clear to 10 A. M. Scatd. ⌒i to 9 P. M., clear afterwards.
30	145.0	...	E. & N.	Clear to 4 A. M. _i & \i to noon. Scatd. ⌒i to 6 P. M., clear afterwards.
31	134.0	...	N. & N. E.	Clear to 8 A. M. Stratouns to 3 P. M. \i afterwards.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of October, 1865.

MONTHLY RESULTS.

	Inches
Mean height of the Barometer for the month, ...	29.848
Max. height of the Barometer occurred at 10 A. M. on the 15th, ..	30.005
Min. height of the Barometer occurred at 4 P. M. on the 2nd, ..	29.640
Extreme range of the Barometer during the month, ...	0.365
Mean of the Daily Max. Pressures, ...	29.917
Ditto ditto Min. ditto, ...	29.790
Mean daily range of the Barometer during the month, ...	0.127

	o
Mean Dry Bulb Thermometer for the month, ...	84.4
Max. Temperature occurred at 5 P. M. on the 9th, ...	93.4
Min. Temperature occurred at 6 A. M. on the 25th, ...	72.6
Extreme range of the Temperature during the month, ...	20.8
Mean of the daily Max. Temperature, ...	91.0
Ditto ditto Min. ditto, ...	78.8
Mean daily range of the Temperature during the month, ...	12.2

Mean Wet Bulb Thermometer for the month, ...	77.4
Mean Dry Bulb Thermometer above Mean Wet Bulb Thermometer, ..	7.0
Computed Mean Dew-point for the month, ...	72.5
Mean Dry Bulb Thermometer above computed Mean Dew-point, ..	11.9
	Inches
Mean Elastic force of Vapour for the month, ...	0.787

	Troy grains
Mean Weight of Vapour for the month, ...	8.42
Additional Weight of Vapour required for complete saturation, ..	3.89
Mean degree of humidity for the month, complete saturation being unity,	0.68

	Inches
Rained No days, Max. fall of rain during 24 hours, ...	Nil.
Total amount of rain during the month, ...	Nil.
Prevailing direction of the Wind, ...	W. & S.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of October, 1865.

MONTHLY RESULTS.

Tables showing the number of days on which at a given hour any particular wind blew, together with the number of days on which at the same hour, when any particular wind was blowing, it rained.

Hour.	N.	Rain on.	N. E.	Rain on.	E.	Rain on.	S. E.	Rain on.	S.	Rain on.	S. W.	Rain on.	W.	Rain on.	N. W.	Rain on.	Calm.	Rain on.	Missed.
								No. of days.											
Midnight.	4		1		3		5		5		3		8		2				
1	5		1		3		4		6		3		7		2				
2	4		1		2		5		6		3		7		3				
3	4		1		2		4		7		3		7		3				
4	4		1		3		3		7		3		7		3				
5	4		1		3		2		8		3		7		3				
6	4		1		1		3		7		4		7		4				
7	4				2		2		7		5		7		4				
8	5				2				4		8		9		3				
9	5		1				1		5		5		10		4				
10	2		3						6		3		11		6				
11	2		1		2		1		1		5		13		6				
Noon.			2		2				2		3		12		10				
1	4				2				2		5		8		10				
2	4				1		1		1		4		13		7				
3	2						1				4		14		10				
4	3				1				3		4		9		11				
5	4				1		1		3		4		12		6				
6	5				2				5		2		12		5				
7	4				2		1		5		2		12		5				
8	2		1		6		1		3		2		12		4				
9	2		1		7		1		3		2		11		4				
10	2		1		6		2		4		3		10		3				
11	3		1		5		4		4		3		8		3				

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of November, 1865.

Latitude 22° 33′ 1″ North. Longitude 88° 20′ 34″ East.

Height of the Cistern of the Standard Barometer above the Sea-level, 18 ft. 11 in.

Daily Means, &c. of the Observations and of the Hygrometrical elements dependent thereon.

Date.	Mean Height of the Barometer at 32° Faht.	Range of the Barometer during the day. Max.	Min.	Diff.	Mean Dry Bulb Thermometer.	Range of the Temperature during the day. Max.	Min.	Diff.
	Inches.	Inches.	Inches.	Inches.	o	o	o	o
1	29.802	29.863	29.732	0.131	78.6	85.7	73.0	12.7
2	.801	.867	.745	.122	79.5	87.3	72.5	14.8
3	.878	.953	.817	.136	81.0	88.2	73.8	14.4
4	.925	30.006	.853	.153	79.7	86.8	71.4	15.4
5	.923	29.989	.876	.113	80.5	85.8	74.8	11.0
6	.931	30.007	.873	.134	79.6	86.8	74.6	12.2
7	.899	29.965	.842	.123	76.5	85.4	67.0	18.4
8	.860	.918	.791	.127	77.4	86.4	68.6	17.8
9	.866	.929	.822	.107	78.5	86.4	70.5	15.9
10	.851	.920	.802	.118	80.7	87.4	75.6	11.8
11	.863	.929	.822	.107	80.6	87.2	75.0	12.2
12	.874	.941	.818	.123	79.4	85.1	74.7	10.4
13	.887	.964	.839	.125	77.4	85.7	71.8	13.9
14	.926	30.008	.850	.158	79.0	87.8	72.2	15.6
15	.970	.051	.921	.130	80.0	86.8	73.2	13.6
16	30.018	.094	.953	.141	79.3	86.5	72.8	13.7
17	.063	.133	30.005	.128	77.8	86.0	71.5	14.5
18	.085	.156	.021	.135	78.0	86.4	71.2	15.2
19	.092	.164	.034	.130	77.0	84.8	70.4	14.4
20	.043	.126	29.976	.150	75.4	83.6	69.0	14.6
21	29.984	.050	.911	.139	73.8	82.2	66.6	15.6
22	.997	.068	.948	.120	73.6	82.2	66.0	16.2
23	30.036	.118	.979	.139	73.7	82.2	66.3	15.9
24	.024	.108	.954	.154	72.8	81.6	66.0	15.6
25	29.974	.058	.900	.158	71.8	81.0	64.5	16.5
26	.949	.014	.888	.126	70.2	77.4	63.6	13.8
27	.980	.060	.919	.141	69.7	78.2	62.3	15.9
28	30.008	.075	.960	.115	69.5	78.2	61.6	16.6
29	.008	.084	.941	.143	70.6	81.1	61.6	19.5
30	29.984	.059	.908	.151	71.2	82.0	63.0	19.0

The Mean Height of the Barometer, as likewise the Dry and Wet Bulb Thermometer Means are derived from the hourly Observations made during the day.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of November, 1865.

Daily Means, &c. of the Observations and of the Hygrometrical elements dependent thereon.—*(Continued.)*

Date.	Mean Wet Bulb Thermometer.	Dry Bulb above Wet.	Computed Dew Point.	Dry Bulb above Dew Point.	Mean Elastic force of Vapour.	Mean Weight of Vapour in a Cubic foot of air.	Additional Weight of Vapour required for complete saturation.	Mean degree of Humidity, complete saturation being unity.
	o	o	o	o	Inches.	T. gr.	T. gr.	
1	71.9	6.7	67.2	11.4	0.664	7.19	3.19	0.69
2	72.9	6.6	68.3	11.2	.688	.43	.23	.70
3	74.1	6.9	69.3	11.7	.711	.64	.50	.69
4	72.8	6.9	68.0	11.7	.681	.35	.37	.69
5	75.0	5.5	71.1	9.4	.753	8.13	2.85	.74
6	70.2	9.4	63.6	16.0	.590	6.36	4.33	.60
7	67.4	9.1	61.0	15.5	.541	5.87	3.88	.60
8	69.4	8.0	63.8	13.6	.593	6.42	.59	.64
9	71.6	6.9	66.8	11.7	.655	7.09	.26	.69
10	74.6	6.1	70.3	10.4	.734	.92	.12	.72
11	73.8	6.8	69.0	11.6	.704	.57	.44	.69
12	72.1	7.3	67.0	12.4	.659	.12	.50	.67
13	70.4	7.0	65.5	11.9	.628	6.81	.20	.68
14	72.2	6.8	67.4	11.6	.668	7.21	.29	.69
15	72.9	7.1	67.9	12.1	.679	.33	.48	.68
16	71.7	7.6	66.4	12.9	.646	6.98	.61	.66
17	70.2	7.6	64.9	12.9	.615	.67	.46	.66
18	70.3	7.7	64.9	13.1	.615	.67	.52	.66
19	69.4	7.6	64.1	12.9	.599	.50	.39	.66
20	67.8	7.6	62.5	12.9	.568	.18	.25	.66
21	66.0	7.8	60.5	13.3	.532	5.81	.17	.65
22	66.0	7.6	60.7	12.9	.536	.84	.09	.65
23	67.1	6.6	62.5	11.2	.568	6.21	2.75	.69
24	65.6	7.2	59.8	13.0	.520	5.68	3.03	.65
25	63.4	8.4	56.7	15.1	.469	.13	.32	.61
26	62.8	7.4	56.9	13.3	.472	.18	2.87	.64
27	61.6	8.1	55.1	14.6	.444	4.89	3.04	.62
28	62.3	7.2	56.5	13.0	.465	5.12	2.76	.65
29	62.5	8.1	56.0	14.6	.458	.02	3.13	.62
30	63.9	7.3	58.1	13.1	.491	.39	2.91	.65

All the Hygrometrical elements are computed by the Greenwich Constants.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of November, 1865.

Hourly Means, &c. of the Observations and of the Hygrometrical elements dependent thereon.

Hour.	Mean Height of the Barometer at 32° Faht.	Range of the Barometer for each hour during the month.			Mean Dry Bulb Thermometer.	Range of the Temperature for each hour during the month.		
		Max.	Min.	Diff.		Max.	Min.	Diff.
	Inches.	Inches.	Inches.	Inches.	o	o	o	o
Mid-night.	29.949	30.099	29.787	0.312	73.3	79.4	65.4	14.0
1	.942	.095	.774	.321	72.6	78.6	64.8	13.8
2	.933	.088	.768	.320	72.1	78.4	64.0	14.4
3	.927	.084	.769	.315	71.4	77.8	63.4	14.4
4	.926	.081	.773	.308	70.7	76.8	62.6	14.2
5	.939	.089	.778	.311	70.1	76.3	61.6	14.7
6	.954	.106	.800	.306	69.6	75.6	61.6	14.0
7	.978	.126	.815	.311	70.0	76.2	61.6	14.6
8	30.001	.146	.836	.310	72.8	79.6	65.0	14.6
9	.021	.164	.852	.312	76.0	83.0	67.7	15.3
10	.019	.161	.861	.300	78.9	84.6	71.2	13.4
11	29.998	.140	.838	.302	81.0	86.4	74.6	11.8
Noon.	.966	.113	.811	.302	82.5	86.2	76.6	9.6
1	.934	.074	.768	.306	83.5	86.8	77.2	9.6
2	.910	.050	.740	.310	84.3	87.8	77.0	10.8
3	.897	.034	.739	.295	84.1	88.2	77.0	11.2
4	.895	.035	.732	.303	83.0	87.0	76.8	10.2
5	.904	.039	.747	.292	81.5	86.2	75.0	11.2
6	.915	.055	.757	.298	79.3	83.8	72.8	11.0
7	.933	.067	.776	.291	77.8	82.4	70.5	11.9
8	.952	.091	.801	.290	76.6	81.8	69.2	12.6
9	.966	.111	.811	.300	75.5	80.8	67.9	12.9
10	.970	.109	.815	.294	74.5	79.4	67.0	12.4
11	.966	.104	.810	.294	73.6	79.3	66.2	13.1

The Mean Height of the Barometer, as likewise the Dry and Wet Bulb Thermometer Means are derived from the Observations made at the several hours during the month.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of November, 1865.

Hourly Means, &c. of the Observations and of the Hygrometrical elements dependent thereon.—*(Continued.)*

Hour.	Mean Wet Bulb Thermometer.	Dry Bulb above Wet.	Computed Dew Point.	Dry Bulb above Dew Point.	Mean Elastic force of Vapour.	Mean Weight of Vapour in a Cubic foot of air.	Additional Weight of Vapour required for complete saturation.	Mean degree of Humidity, complete saturation being unity.
	o	o	o	o	Inches.	Troy grs.	Troy grs.	
Midnight.	68.6	4.7	64.8	8.5	0.613	6.71	2.13	0.76
1	67.9	4.7	64.1	8.5	.599	.55	.11	.76
2	67.4	4.7	63.6	8.5	.590	.45	.08	.76
3	66.9	4.5	63.3	8.1	.584	.41	1.94	.77
4	66.4	4.3	63.0	7.7	.578	.35	.83	.78
5	66.0	4.1	62.7	7.4	.572	.30	.73	.79
6	65.6	4.0	62.4	7.2	.567	.24	.66	.79
7	65.8	4.2	62.4	7.6	.567	.23	.77	.78
8	66.9	5.9	62.2	10.6	.563	.15	2.56	.71
9	68.1	7.9	62.2	13.4	.570	.20	3.40	.65
10	69.4	9.5	62.7	16.2	.572	.19	4.28	.59
11	70.2	10.8	62.6	18.4	.570	.14	5.00	.55
Noon.	70.7	11.8	62.4	20.1	.567	.08	.56	.52
1	70.9	12.6	62.1	21.4	.561	.01	.99	.50
2	71.5	12.8	62.5	21.8	.568	.07	6.21	.49
3	71.0	13.1	61.8	22.3	.555	5.94	.27	.49
4	70.9	12.1	62.4	20.6	.567	6.06	5.76	.51
5	71.3	10.2	64.2	17.3	.601	.46	4.85	.57
6	71.6	7.7	66.2	13.1	.642	.93	3.66	.65
7	71.3	6.5	66.7	11.1	.653	7.07	.06	.70
8	70.7	5.9	66.6	10.0	.651	.07	2.70	.72
9	70.1	5.4	66.3	9.2	.644	.02	.44	.74
10	69.5	5.0	66.0	8.5	.638	6.95	.23	.76
11	68.9	4.7	65.6	8.0	.630	.89	.04	.77

All the Hygrometrical elements are computed by the Greenwich Constants.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of November, 1865.

Solar Radiation, Weather, &c.

Date.	Max. Solar radiation.	Rain Gauge 5 feet above Ground.	Prevailing direction of the Wind.	General Aspect of the Sky.
	o	Inches.		
1	133.0	...	N.	╲i.
2	137.8	...	N. & N. W.	╲i to 1 P. M. clear afterwards. Slightly foggy from 9 to 11 P. M.
3	141.8	...	N. & N. W. & W.	Clear to 10 A. M. ╲_i & ⌒i to 3 P. M., clear afterwards.
4	138.7	...	N. & N. W.	Clear to noon, Scatd. ⌒i to 5 P. M., clear afterwards.
5	141.0	...	N. & N. W.	Clear to 6 A. M. ⌒i to 5 P. M., clear afterwards.
6	140.0	...	N. & N. W.	Clear. Slightly foggy at midnight.
7	140.2	...	N. W. & N.	Clear.
8	138.0	...	N. W. & N.	Clear.
9	131.8	...	N. & N. W. & W.	Clear to 6 A. M. ╲i to 6 P. M., clear afterwards.
10	120.0	...	N.	⌒i to 8 A. M. ╲⌒i to 6 P. M., clear afterwards.
11	139.0	...	N.	╲i nearly the whole day.
12	131.0	...	N.	╲⌒i to 6 P. M., clear afterwards.
13	139.9	...	N.	Scatd. ╲i to 5 A. M. light clouds to 11 A. M. ╲i to 5 P. M., clear afterwards.
14	146.4	...	N. & N. E.	Clear to 4 A. M., clouds of different kinds to Noon, ╲i to 5 P. M., clear afterwards.
15	134.8	...	N.	Clear to 4 A. M. Scatd. ╲i to 6 P. M., clear afterwards.
16	136.2	...	N.	Clear to 10 A. M., ╲⌒—i to 7 P. M., clear afterwards.
17	137.0	...	N.	Clear.
18	139.0	...	N.	Clear.
19	139.4	...	N.	Clear.
20	141.0	...	N.	Clear to 6 A. M. Scatd. ╲i to 6 P. M., clear afterwards. Slightly foggy at 9 & 10 P. M.
21	135.0	...	N. & E.	Clear. Slightly foggy to 1 A. M.
22	136.0	...	N. & E.	Clear.
23	135.0	...	N. W. & N. & E.	Clear.
24	136.2	...	N.	Clear to 5 A. M. Scatd. ╲i to 6 P. M., clear afterwards.
25	133.4	...	N.	Clear to 4 A. M. Scatd. ╲i afterwards.
26	127.0	...	N.	Clear to 3 A. M. ╲i afterwards.

╲i Cirri, —i Strati, ⌒i Cumuli, ╲_i Cirro-strati, ⌒—i Cumulo-strati, ╲⌒—i Nimbi ╲⌒i Cirro-cumuli.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of November, 1865.

Solar Radiation, Weather, &c.

Date.	Max. Solar radiation.	Rain Gauge 5 feet above Ground.	Prevailing direction of the Wind.	General Aspect of the Sky.
	o	Inches		
27	129.0	...	N. W. & N.	\i to 1 A. M. clear to 5 A. M. \i to 6 P. M., clear afterwards. Slightly foggy at 7 P. M.
28	130.5	...	N. W. & W.	Clear to 5 A. M. \i to 7 P. M., clear afterwards.
29	136.0	...	W.	Clear. Slightly foggy at 1 A. M.
30	138.8	...	W.	Clear. Slightly foggy at 10 P. M.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of November, 1865.

Monthly Results.

	Inches
Mean height of the Barometer for the month, ...	29.950
Max. height of the Barometer occurred at 9 A. M. on the 19th, ..	30.164
Min. height of the Barometer occurred at 4 P. M. on the 1st, ..	29.732
Extreme range of the Barometer during the month, ...	0.432
Mean of the Daily Max. Pressures, ...	30.023
Ditto ditto Min. ditto, ...	29.890
Mean daily range of the Barometer during the month, ...	0.133

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	o
Mean Dry Bulb Thermometer for the month, ...	76.4
Max. Temperature occurred at 3 P. M. on the 3rd, ...	88.2
Min. Temperature occurred at 6 & 7 A. M. on the 28th & 29th, ..	61.6
Extreme range of the Temperature during the month, ...	26.6
Mean of the daily Max. Temperature, ...	84.4
Ditto ditto Min. ditto, ...	69.5
Mean daily range of the Temperature during the month, ...	14.9

Mean Wet Bulb Thermometer for the month, ...	69.1
Mean Dry Bulb Thermometer above Mean Wet Bulb Thermometer, ..	7.3
Computed Mean Dew-point for the month, ...	64.0
Mean Dry Bulb Thermometer above computed Mean Dew-point, ..	12.4
	Inches
Mean Elastic force of Vapour for the month, ...	0.597

	Troy grains
Mean Weight of Vapour for the month, ...	6.49
Additional Weight of Vapour required for complete saturation, ..	3.23
Mean degree of humidity for the month, complete saturation being unity,	0.67

	Inches
Rained No days, Max. fall of rain during 24 hours, ...	Nil.
Total amount of rain during the month, ...	Nil.
Prevailing direction of the Wind, ...	N. & N. W.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of November, 1865.

MONTHLY RESULTS.

Tables showing the number of days on which at a given hour any particular wind blew, together with the number of days on which at the same hour, when any particular wind was blowing, it rained.

Hour.	N.	Rain on.	N. E.	Rain on.	E.	Rain on.	S. E.	Rain on.	S.	Rain on.	S. W.	Rain on.	W.	Rain on.	N. W.	Rain on.	Calm.	Rain on.	Missed.
								No. of days.											
Midnight.	17		2		2								2		6				1
1	18		2		2								3		5				
2	19				2		1						3		5				
3	21				2								3		4				
4	19				2								3		6				
5	22				1								3		4				
6	24												3		3				
7	22												3		5				
8	24		1										2		3				
9	22		5										2		1				
10	23		5										2						
11	23		3		2								2						
Noon.	23		1										2		4				
1	22												2		6				
2	14		2		2								2		9				1
3	15		2		1								2		10				
4	18				1								3		8				
5	18		1		1								3		7				
6	17		1		1								4		7				
7	16		1		2								4		7				
8	14		1		3								4		8				
9	14		1		3								4		8				
10	15		1		2								3		9				
11	16		1		2				1				3		7				

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of December, 1865.

Latitude 22° 33′ 1″ North. Longitude 88° 20′ 34″ East.

Height of the Cistern of the Standard Barometer above the Sea-level, 18 ft. 11 in.

Daily Means, &c. of the Observations and of the Hygrometrical elements dependent thereon.

Date.	Mean Height of the Barometer at 32° Faht.	Range of the Barometer during the day. Max.	Min.	Diff.	Mean Dry Bulb Thermometer.	Range of the Temperature during the day. Max.	Min.	Diff.
	Inches.	Inches.	Inches.	Inches.	°	°	°	°
1	29.970	29.049	29.906	0.143	72.9	83.5	65.1	18.4
2	.984	.051	.928	.123	72.7	82.6	66.0	16.6
3	30.011	.079	.955	.124	75.2	85.6	67.4	18.2
4	.020	.114	.960	.154	74.9	83.6	67.8	15.8
5	29.999	.071	.929	.142	74.0	82.2	68.2	14.0
6	30.031	.093	.984	.109	72.8	81.4	64.8	16.6
7	.013	.098	.957	.141	72.9	81.8	65.0	16.8
8	29.972	.051	.927	.124	75.3	83.4	69.4	14.0
9	30.010	.090	.964	.126	74.3	82.2	67.8	14.4
10	.042	.134	.995	.139	69.9	78.8	61.4	17.4
11	.060	.164	.975	.189	67.6	76.3	59.5	16.8
12	.062	.154	30.005	.149	64.9	74.5	56.8	17.7
13	.029	.107	29.950	.157	66.3	76.2	58.0	18.2
14	.054	.139	.993	.146	67.1	77.4	58.6	18.8
15	.066	.150	.995	.155	68.3	77.8	60.0	17.8
16	.053	.130	.997	.133	68.3	77.8	60.2	17.6
17	.031	.103	.985	.118	68.3	78.7	60.0	18.7
18	.021	.082	.971	.111	69.0	79.0	60.6	18.4
19	.037	.112	.974	.138	69.5	79.4	60.2	19.2
20	.092	.185	30.048	.137	70.4	80.6	61.5	19.1
21	.101	.172	.043	.129	72.0	82.6	62.8	19.8
22	.126	.196	.064	.132	71.9	81.2	63.6	17.6
23	.101	.178	.043	.135	71.0	80.4	62.8	17.6
24	.068	.139	.005	.134	71.7	81.0	64.3	16.7
25	.060	.156	29.975	.181	71.9	81.8	63.8	18.0
26	.015	.096	.940	.156	72.7	82.0	64.8	17.2
27	29.974	.052	.909	.143	74.2	81.7	67.0	14.7
28	.940	.016	.883	.133	72.8	81.0	66.5	14.5
29	30.011	.070	.965	.105	71.5	76.2	68.4	7.8
30	.050	.146	.976	.170	68.1	74.6	62.6	12.0
31	.035	.134	.966	.168	68.5	78.0	60.0	18.0

The Mean Height of the Barometer, as likewise the Dry and Wet Bulb Thermometer Means are derived from the hourly Observations made during the day.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of December, 1865.

Daily Means, &c. of the Observations and of the Hygrometrical elements dependent thereon.—*(Continued.)*

Date.	Mean Wet Bulb Thermometer.	Dry Bulb above Wet.	Computed Dew Point.	Dry Bulb above Dew Point.	Mean Elastic force of Vapour.	Mean Weight of Vapour in a Cubic foot of air.	Additional Weight of Vapour required for complete saturation.	Mean degree of Humidity, complete saturation being unity.
	o	o	o	o	Inches.	T. gr.	T. gr.	
1	66.2	6.7	60.8	12.1	0.537	5.88	2.85	0.67
2	68.3	4.4	64.8	7.9	.613	6.72	1.96	.77
3	67.8	7.4	62.6	12.6	.570	.20	3.17	.66
4	68.0	6.9	63.2	11.7	.582	.33	2.95	.68
5	68.9	5.1	65.3	8.7	.623	.81	.23	.75
6	66.2	6.6	60.9	11.9	.539	5.90	.81	.68
7	65.9	7.0	60.3	12 6	.528	.78	.95	.66
8	70.1	5.2	66.5	8.8	.648	7.06	.34	.75
9	66.1	8.2	60.4	13.9	.530	5.78	3.34	.63
10	61.5	8.4	54.8	15.1	.440	4.83	.15	.61
11	58.9	8.7	51.9	15.7	.398	.40	.04	.59
12	57.4	7.5	51.4	13.5	.392	.35	2.50	.64
13	59.9	6.4	54 8	11.5	.440	.86	.29	.68
14	61.0	6.1	56.1	11.0	.459	5.09	.23	.70
15	62.6	5.7	58.0	10.3	.489	.40	.20	.71
16	62.0	6.3	57.0	11.3	.473	.22	.38	.69
17	62.0	6.3	57.0	11.3	.473	.22	.38	.69
18	62.4	6.6	57.1	11.9	.475	.23	.53	.67
19	62.7	6.8	57.3	12.2	.478	.26	.62	.67
20	63.8	6.6	58.5	11.9	.498	.47	.63	.68
21	64.8	7.2	59.0	13.0	.506	.54	.96	.65
22	65.3	6.6	60.0	11.9	.523	.73	.75	.68
23	65.0	6.0	60.2	10.8	.527	.78	.47	.70
24	65.8	5.9	61.1	10.6	.543	.95	.48	.71
25	66.8	5.1	62.7	9.2	.572	6.27	.21	.74
26	67.5	5.2	63.3	9.4	.584	.39	.29	.74
27	68.5	5.7	64.5	9.7	.607	.62	.47	.73
28	68.5	4.3	65.1	7.7	.619	.78	1.93	.78
29	67.9	3.6	65.0	6.5	.617	.77	.61	.81
30	62.1	6.0	57.3	10.8	.478	5.27	2.28	.70
31	61.8	6.7	56.4	12.1	.464	.11	.54	.67

All the Hygrometrical elements are computed by the Greenwich Constants.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of December, 1865.

Hourly Means, &c. of the Observations and of the Hygrometrical elements dependent thereon.

Hour.	Mean Height of the Barometer at 32° Faht.	Range of the Barometer for each hour during the month.			Mean Dry Bulb Thermometer.	Range of the Temperature for each hour during the month.		
		Max.	Min.	Diff.		Max.	Min.	Diff.
	Inches.	Inches.	Inches.	Inches.	o	o	o	o
Mid-night.	30.035	30.153	29.954	0.199	67.3	72.8	60.8	12.0
1	.028	.148	.936	.212	66.5	72.8	59.8	13.0
2	.020	.133	.912	.221	66.0	72.2	59 0	13.2
3	.012	.124	.905	.219	65.3	72.0	58.8	13.2
4	.010	.107	.888	.219	64.6	71.2	58.4	12.8
5	.021	.114	.899	.215	64.1	71.0	58.0	13.0
6	.035	.126	.910	.216	63.6	69.4	57.0	12.4
7	.058	.145	.945	.200	63.5	70.0	56.8	13.2
8	.087	.174	.991	.183	66.3	72.3	60.4	11.9
9	.109	.194	30.005	.189	69.8	75.3	63.0	12.3
10	.111	.196	.016	.180	73.3	79.2	67.8	11.4
11	.092	.182	.004	.178	75.8	81.8	71.0	10.8
Noon.	.058	.144	29.974	.170	77.7	83.0	72.2	10.8
1	.022	.116	.936	.180	79.0	84.7	74.1	10.6
2	29.995	.088	.907	.181	79.9	85.6	74.2	11.4
3	.980	.066	.887	.179	79.9	84.8	74.5	10.3
4	.976	.064	.883	.181	78.5	83.5	73.4	10.1
5	.985	.067	.886	.181	76.9	81.3	71.8	9.5
6	.996	.084	.901	.183	74.2	78.3	68.2	10.1
7	30.014	.104	.924	.180	72.3	76.2	66.0	10.2
8	.030	.123	.953	.170	71.0	75.2	65.0	10.2
9	.043	.150	.974	.176	69.8	74 1	63.4	10.7
10	.048	.159	.979	.180	68.8	73 8	62.6	11.2
11	.044	.157	.972	.185	68.1	73.0	61.8	11.2

The Mean Height of the Barometer, as likewise the Dry and Wet Bulb Thermometer Means are derived from the Observations made at the several hours during the month.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of December, 1865.

Solar Radiation, Weather, &c.

Date.	Max. Solar radiation.	Rain Gauge 5 feet above Ground.	Prevailing direction of the Wind.	General Aspect of the Sky.
	o	Inches.		
28	138.0	...	W. & S.	Clear to 7 A. M. ~i afterwards.
29	128.0	...	N. & W.	Overcast to 6 P. M. clear afterwards, foggy at 9 P. M.
30	132.0	...	N.	Clear, foggy at 11 P. M.
31	130.0	...	N. & W. & N. W.	Clear, foggy at Midnight & 1 A. M. & at 8 P. M.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of December, 1865.

Monthly Results.

	Inches
Mean height of the Barometer for the month, ...	30.034
Max. height of the Barometer occurred at 10 A. M. on the 22nd, ..	30.196
Min. height of the Barometer occurred at 4 P. M. on the 28th, ..	29.883
Extreme range of the Barometer during the month, ...	0.313
Mean of the Daily Max. Pressures,..	30.113
Ditto ditto Min. ditto, ...	29.973
Mean daily range of the Barometer during the month, ...	0.140

	o
Mean Dry Bulb Thermometer for the month, ...	71.0
Max. Temperature occurred at 2 P. M. on the 3rd, ...	85.6
Min. Temperature occurred at 7 A. M. on the 12th, ...	56.8
Extreme range of the Temperature during the month, ...	28.8
Mean of the daily Max. Temperature, ...	80.1
Ditto ditto Min. ditto, ...	63.4
Mean daily range of the Temperature during the month, ...	16.7

Mean Wet Bulb Thermometer for the month, ...	64.7
Mean Dry Bulb Thermometer above Mean Wet Bulb Thermometer, ..	6.3
Computed Mean Dew-point for the month, ...	59.7
Mean Dry Bulb Thermometer above computed Mean Dew-point, ..	11.3
	Inches
Mean Elastic force of Vapour for the month, ...	0.518

	Troy grains
Mean Weight of Vapour for the month, ...	5.69
Additional Weight of Vapour required for complete saturation, ..	2.56
Mean degree of humidity for the month, complete saturation being unity,	0.69

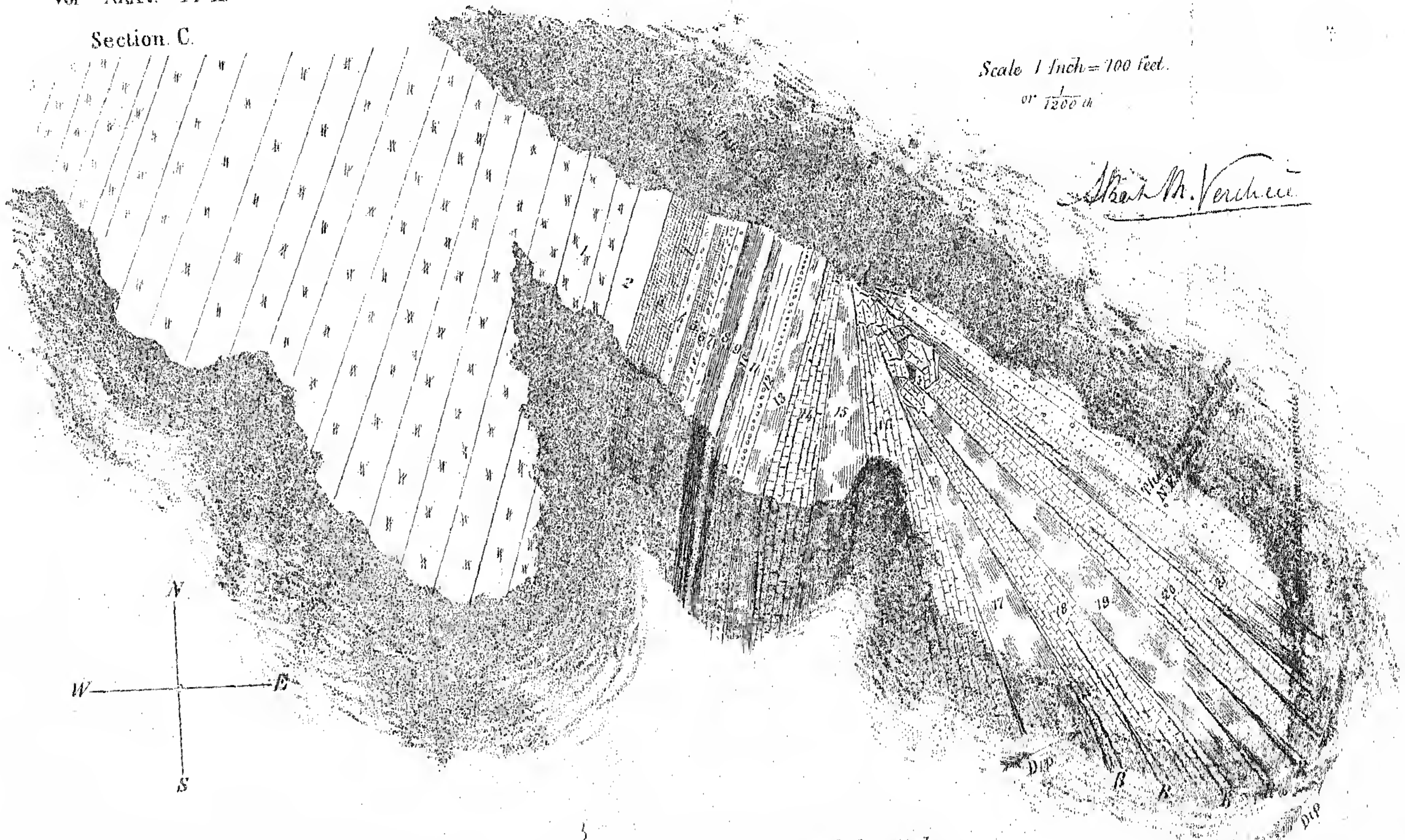
	Inches
Rained No days, Max. fall of rain during 24 hours, ...	Nil.
Total amount of rain during the month, ...	Nil.
Prevailing direction of the Wind, ...	N. & W. & S.

Journal As. Soc.
Vol XXXV. Pt II.

Section. C.

Scale 1 Inch = 100 feet.
or $\frac{1}{1200}$ th

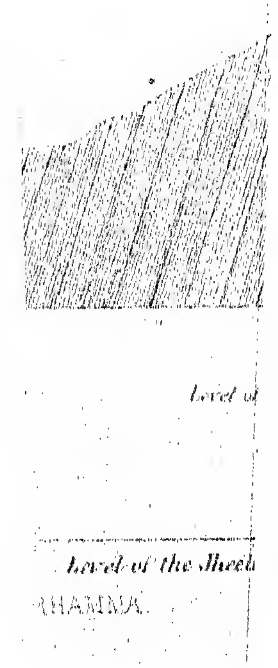
Alexr M. Verchere



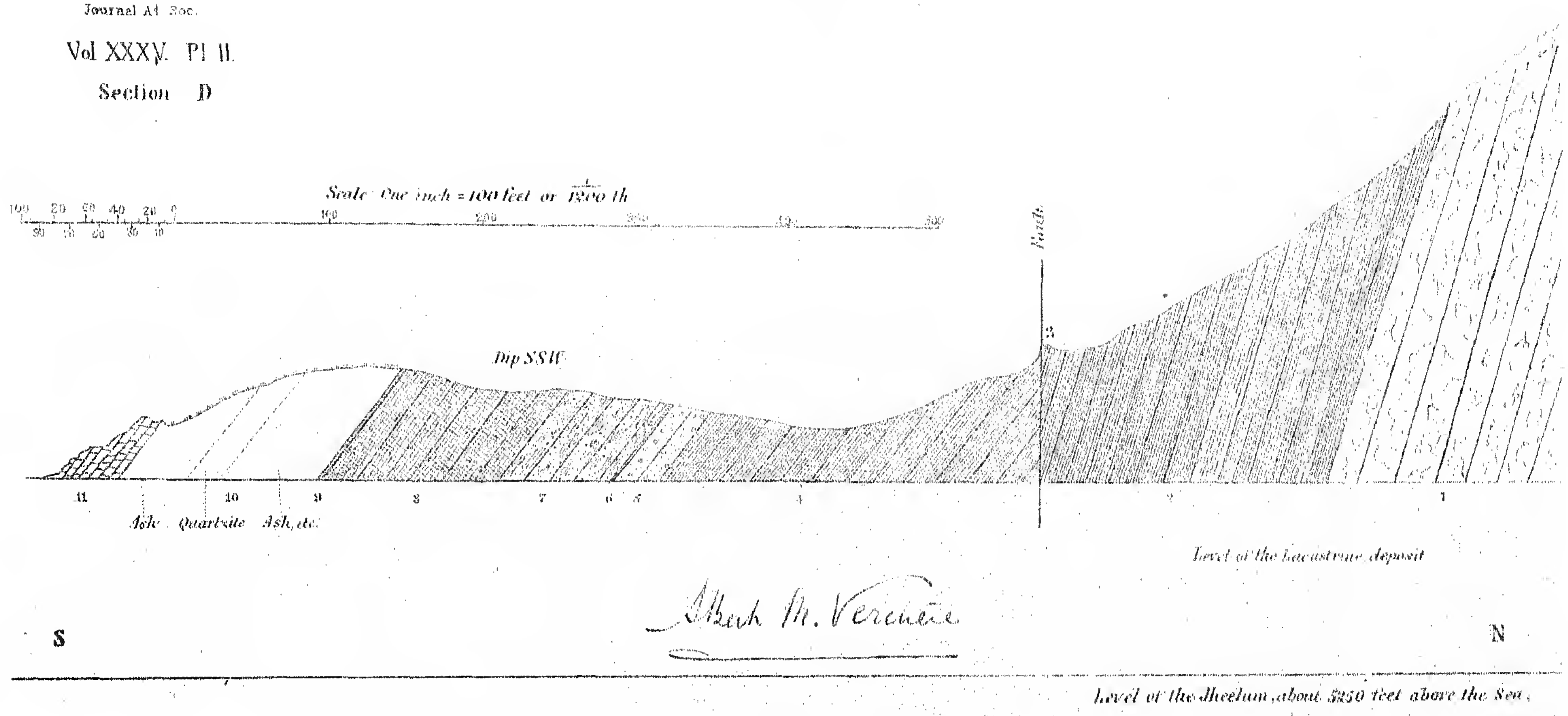
HORIZONTAL SECTION of the ZEEAWAN SPUR
of the ZEBANWAN.
Showing the fan like disposition of the courses of limestone and Brown Shales.

A. Crushing of the beds at the small end of the Fan.

B.B.B. Openings between the beds and courses of rocks at the expanded end of the Fan.



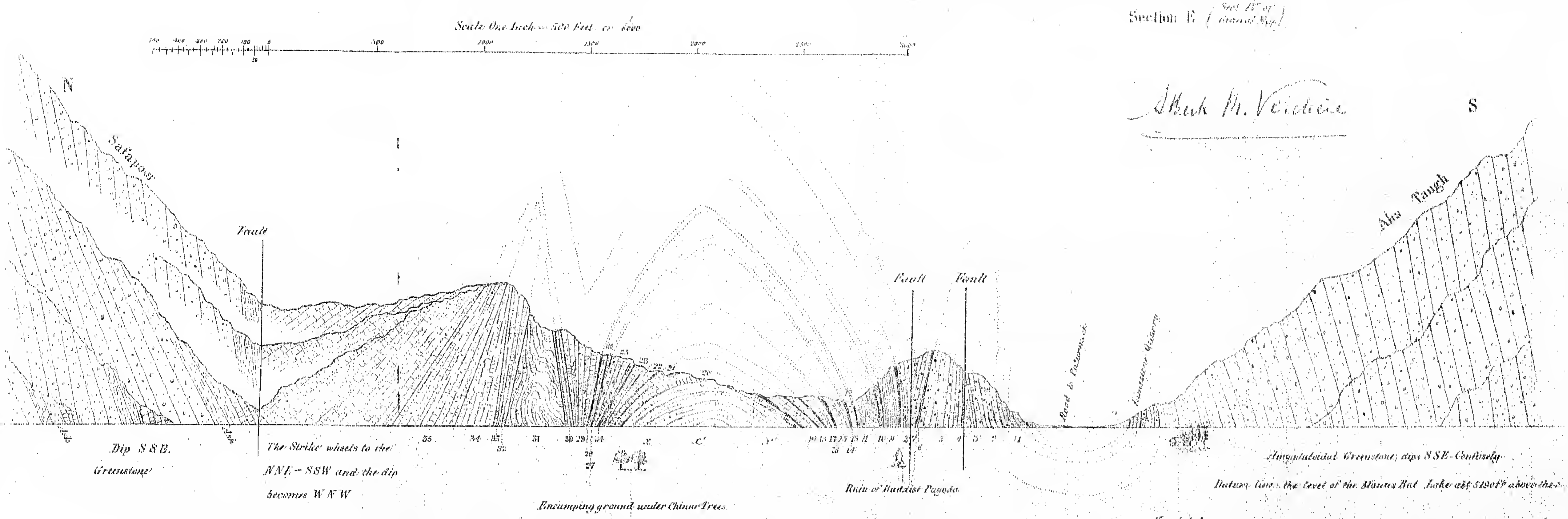
Journal As. Soc.
Vol XXXV. Pl II.
Section D



SECTION across the Spur of the KAMLAWAN above the Village of MURHAMMA.

Journal As. Soc. Vol XXXV. Pl II.

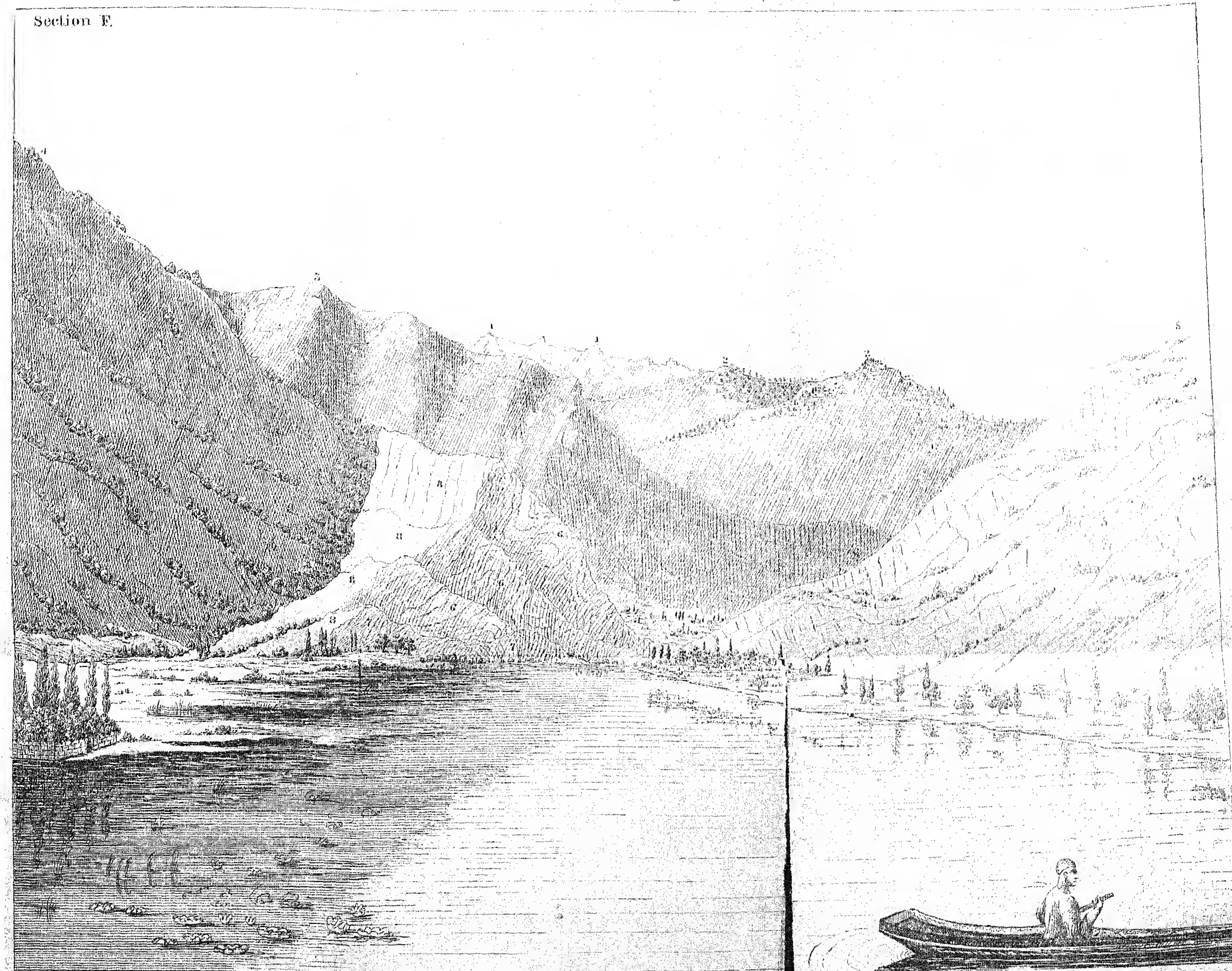
Section E (Sect. IV of General Map)



SECTION of the MANUS BAL LIMESTONE
between the SAFAPOOR and AHA TANGH

Lith: By R. Niven Survr. General's Office Calcutta Augt. 1866.

Section F.



1. The porphyritic Summit of Kutwal (14271 ft.). 2. The Northern Extremity of the Saij-aha (11334) composed of Greenstone, Ash, &c. 3. One of the Spurs of the Safapoor (10309), similarly composed. 4. The Spur of Safapoor which overhangs Manus Bal (Lake) Greenstone, Basalt, Ash, &c. 5. The Aha-Tang, similarly composed. 6. The beds of Limestone between the Safapoor and Aha-Tang; wonderfully contorted by having been squeezed between the two hills. 7. The spur of Limestone of which a detailed section is given, (see Section) 8. Face of the beds of limestone, dipping W.N.W. 9 small beds of Limestone conformable to the Ash, and Greenstone, dipping S.S.E. 10. Fault.

Albert M. Verchère

// JOURNAL

OF THE

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Part II.—PHYSICAL SCIENCE.

No. III.—1866.

Kashmir, the Western Himalaya and the Afghan Mountains, a geological paper by Albert M. Verchère, *Esq., Bengal Medical Service; with a note on the fossils by* M. Edouard de Verneuil, *Membre de l'Académie des Sciences, Paris.*

(Continued from page 133.)

Leaving with regret the Zeeawan spur, we will continue our examination of the Zebanwan mountain along its southern aspect. (See Map B.) (Section III. on General Map.)

We first cross a considerable mass of volcanic rocks, well stratified, and which we will not stop to describe, as they are similar to the felspathic ashes, black slates and the amygdaloid seen before. They present, however, a few layers of a coarsely crystalline limestone, without fossils and interbedded with layers of ash; some of this limestone is quite black and remarkably well crystallized in small crystals of jet-black spar. It would be a valuable ornamental marble, if found in some quantity. I have only seen it in thin and small patches, accompanying an amygdaloidal dust-stone of fine texture, but much decayed and nearly as black as the limestone. These patches of black rock are well seen on the slope of the long spurs which descend towards the S. E., from the highest summits of the Zebanwan. These volcanic rocks dip easterly, and their inclination is not more than 20° to 25°.

Having crossed a ravine, we arrive at the spurs over Zowoor, where we find the following beds along one section, from W. S. W. to E. N. E. We begin with No. 4 of the Section: the Nos. 1, 2 and 3 refer to the volcanic rocks and black limestone just described.

1. .... Amygdaloidal greenstone, dips E. S. E.
2. .... Ash interbedded with thin beds of highly crystalline azoic limestone.
3. .... Ash interbedded with black crystalline limestone in thin patches.
4. Amygdaloid; dip E. S. E. 20°.
5. Quartzite, white and stratified. It becomes gradually sandy and coloured blue, yellow or grey in places, ... 15 ft.
6. Crystalline limestone with the debris of fossils, undeterminable, 5 ft.
7. Lenticular beds of coarse granular limestone, full of *Athyris* sp.? (see Pl. II. fig. 1 and 1a) and *Productus Flemingi*,............................ 1 foot.
8. Limestone; grey, weathering brown, presenting abundant sections of *Orthoceras* and a few *Fenestellides*, ... 10 ft.
9. Coarse limestone; *Fenestellides, Producti*, &c. passes into.
10. Calcareo-ferruginous, brown shales with some fossils: 9 and 10, about .... 40 ft.

These beds 6, 7, 8, 9 and 10 are therefore the same beds as there seen at Zecawan, or they are in other words, Zecawan limestone. They all dip E.S.E. 20°.

11. Limestone, thin bedded and shaly: no fossils, ... 5 ft.

A fault occurs here, and the following beds are seen on the eastern side of it.

12. Limestone of the Zecawan bed brought up again. It presents the same succession as above, viz. an Orthoceras bed, a Fenestellide bed, and a brown shale bed; the Fenestellide beds are, however, less abundant, and the lenticular Athyris ones were not seen, ... 40 ft.

27. Resting on this limestone, we find other beds of limestone having a very different aspect. In fact we have the beginning of the Wecan bed of carboniferous limestone. The fauna changes considerably: no *Producti* are found, no *Fenestellides*, no great flat *Orthidæ*, but instead a very great number of small bivalves, much broken and comminuted, and here and there in lenticular beds, where fossils of one or two species have been heaped together, some small *Brachiopoda* of the genera *Spiriferina* and *Terebratula*; some large mussel-shaped bivalves which are probably *Anthracosiæ* or some other near sub-genus of *Cardinia*; some large and sometimes extremely gibbose *Aviculo-pectens*; some *Pectens* four inches across; *Goniatites* and an innumerable variety of *Encrinite* stems of all sizes. The appearance of the rock will be noticed as we get on with our section.

13. A light blue limestone, argillaceous and compact, weathering rugose like frosted glass, but without losing its fine, lustreless, clay-like, pale blue colour. It contains many remains of fossils in a bad state of preservation,... 30 ft.

A fault from N. N. W.—S S. E.; downthrow S. W. The fault is met near the end of the spur by another running W. S. W.—E. N. E. The end of the spur, detached, as it were, by these two faults, strikes S. E.—N. W. and dips N. E. 20°. The rock of this detached bed is a shaly limestone; the fossils are small and ill-preserved; they occur in patches, one or two feet of the bed presenting a great number of remains, whilst hardly a trace of organisms is to be seen for some yards. It is about 50 feet thick,......................... 50 ft.

Another fault from N. N. W.—S. S. E.; downthrow S. W. The effect of this fault has been to bring up again the bed of Zeeawan limestone, and we therefore have the following bed to the N. E. of the fault.

14. A coarse micaceous marly slate, without fossils, and passing gradually upwards into sandy shales of a dark brown colour and containing *Producti*, *Orthidæ* and *Spirifers* in a very bad state of preservation. These dark shales are identical in appearance and in some of their fossils with the brown shales of the Zeeawan bed, but the *Bryozoa*, so extensively developed in other localities, appear to be totally absent, and some small bivalves, which are found in the Weean bed and have not been seen in the Zeeawan bed, were discovered here.* These differences however may be easily accounted for by a difference of depth of the sea at the time the Zeeawan limestone and shale were deposited. The sandy and coarse micaceous slates seem to indicate a shallow sea with a drifting current on a shelving coast, a physical arrangement which may be a tolerable habitat for the large *Brachiopoda*, but unsuitable to the delicate *Bryozoa*.

This Zeeawan bed is succeeded by a shaly limestone, similar to that which is seen before the fault, that is to say Weean limestone. It has a well marked cleavage, due probably to its argillaceous impurities, and this cleavage is not unfrequently more conspicuous than the stratification.

The end of the spur is, like the preceding spur, cut off by a transverse fault W. S. W.—E. N. E. and the detached end dips E. N. E. 20°, whilst the body of the spur, above the transverse fault, dips E. S. E. 20°, the cleavage noted above dips N. W. 70°.

The thickness of these two beds together is about 100 feet; they form the whole of the spur above the village of Koonmoo, ... 100 ft.

28. Above Koonmoo, in the angle formed by the divergence of the two arms of the spur, is a spring with a Zyarat called Shŏkŭm.

* A similar mixture of Zeeawan and Weean fossils is found in some parts of the Rotta Roh in the Punjab. See Chapter III. para. 60.

The rocks which are above this spring form a little knoll very insignificant geographically, but interesting for its fossils. These are often converted into hæmatite, sometimes crystalline, sometimes powdery. The rock of the bed is mostly a hard, cherty, pinkish limestone, and in this are lenticular beds of a soft, granular, pale french-grey limestone, with innumerable minute black dots which are the crystallized stems of a very slender crinoid. These minute rings are sometimes a round plate and sometimes a five radiated star. The rock is sometimes coloured pink by iron, and then the crinoid-rings are dark red instead of black. It is fœtid and it contains the large *Anthracosiæ* (Pl VI. fig. 3,) and the Aviculo-pectens mentioned before, and also the little shell Pl. VIII. fig. 5. This spur contains also a very compact, dark, nearly black limestone, with a very fine grain, but with only a few fossils and encrinite-rings. It is a similar bed which has furnished the blocks of which the beautiful black marble pillars of the Shalimar Bagh are made of. It takes a fine polish, and is evidently very durable. It is probable that this bed of black limestone crosses over to the valley of the Arrah river, and has been quarried there for these pillars.*

The remainder of the little spur is made up of calcareous, micaceous sandstone without fossils (?). The thickness of the beds forming this spur, is about .... 60 ft.

Then we have again beds of limestone, shaly and sandy, much cracked and fissured, and with only the debris of fossils. The harder portion of the rock is blue, and is traversed by innumerable white lines cutting one another in all directions. It dips E. S. E. 20°.

It is succeeded by a bed of blue argillaceous limestone, weathering rugose, and traversed by thin streaks of yellow, ochrous limestone, and containing fossils in abundance, amongst others a plaited *Spiriferina* which appears common in some layers, whilst it is rare in others. Crinoid stems are also very abundant, occurring as it were in patches.

The above mentioned bed is covered in by a grey micaceous sandstone, weathering pale brown and containing the fragments of fossils, but no *Spiriferinæ*.

The total thickness of the three last beds mentioned is above ... 150 ft.

Crossing the dry bed of a torrent and a great deal of rubbish which apparently covers a fault, the sixth spur is reached, and presents the following layers :

* These pillars are generally described by travellers as black porphyry, a mistake which a very little attention would have prevented, as the sections of fossils are to be seen on the polished surface of the columns.

a. The bed with the spur brought up again after the fault, ... 20 ft.

b. The micaceous sandstone, thin and false-bedded, with well marked cleavage, ... 16 ft.

c. Fœtid pale brown, calcareous sandstone, viz. false-bedded; no fossils; dips. E. S. E. 30° .... 1½ ft.

d. Shales; no fossils,.. 1 foot.

e. Limestone, compact and dark grey, and weathering brown. It is much shivered, and is divided by innumerable white lines crossing each other. No fossils except what appear to be worm-burrows filled with sandy ochre, 15 ft.

f. Very argillaceous limestone of a pale blue colour, with patches of a dirty yellow or pale brown colour, ... 3 ft.

29. I consider that these beds are the top of the Weean division of the carboniferous limestone of the Himalaya, as the following beds show a very great difference in their fauna, which is nearly entirely confined to gasteropods and corals, the gasteropods presenting a great variety of shape and size. The corals of the *Cyathophyllidæ* are abundant and of considerable dimensions. The crinoid stems, some of them minute and starred, continue to be seen everywhere. The beds characterized by gasteropods and corals form the Kothair bed, which we shall see better developed elsewhere.

Continuing our section, we have therefore, resting on the argillaceous limestone, the following layers:

g. Limestone, fine grained, blue, compact and argillaceous, with patches of dirty yellow. It contains many fragments of fossils, nearly entirely gasteropods. Some of these are two inches in length. Starry rings of crinoid stems abundant. The limestone becomes gradually of a richer blue colour, some portions being indeed light blue; it weathers rugose like frosted glass. The upper part contains no gasteropods, but fossil roots and rootlets the size of the finger. It is about 25 feet thick, ... 25 ft.

This is all we see here of the Kothair bed, as a fault running N. S. brings up again the Weean bed; but this patch of the Kothair is interesting, as showing its relation to the Weean bed, a relation which I have not been able to trace so well anywhere else. The Weean and Kothair beds are quite conformable.

On the other side of the fault we find:

a. A limestone, bluish-grey and compact; weathering sandy and dull grey. It is divided in layers by several sandy partings. It contains only a few encrinite stems and dotted white patches which are probably decomposed fossils. It is shivered and traversed by innumerable white lines,...... 20 ft.

b. Brown fœtid limestone, full of a transverse species of a plaited *Spiriferina* and a globular *Terebratula.* It is probably a lenticular bed, and takes the place of the Spirifer bed noted above, ... 3 ft.

c. Limestone like *a.*

The end of this spur is cut by a transverse fault in the same manner as we have seen in the preceding spurs. The cut off beds are much disturbed, being vertical at the tops of the ridge, and dipping N. E. at high angles along the slope.

Beyond this is I have not examined this fine section of the limestone of Kashmir. I was never allowed to visit it again, as I was suddenly ordered away from Srinuggur, my professional services being required elsewhere. Had I had time, I intended to follow the section across the range into Nawan and down to the bottom of the Harrah Valley.

30. From the brow of the last spur which I have visited, a fine view is obtained of the next spur, which is remarkable for a great twist of the strata which compose it. The limestone is extremely white and resembles chalk-cliffs at a distance. We shall, however, see this white limestone at Manus Bal, and find that it is probably a portion of the Weean bed altered by heat. We shall find it similarly altered at Islamabad.

The whole mass of hills of Nawan appears to be limestone. The summits of Boorwaz and Batgool appear behind the range, presenting high rugged peaks of porphyry. To our right, the limestone forms a small chain which advances for some miles into the Pampur valley, and behind this chain a long line of mountains, also entirely composed of limestone, runs N.—S. to join the Wastarwan. (See maps B. and C.)

31. The little chain which descends into the Pampur valley terminates over the village of Weean. At its extremity, the Weean limestone, or middle bed of carboniferous limestone of Kashmir, is well developed, and we will now proceed to examine this locality. It is, to me, the classical ground of the Weean limestone, as the Zeeawan spur is that of the Zeeawan Bed.

Section of the hills above the village of Weean in the Pampur valley. *(See fig. 7.)*

The little hillocks above the villages of Weean and Kohew, are separated from the main hill by a fault running W.—E. The beds have moreover been folded on themselves and dip due W. (at Weean), with an angle of 55°, whilst in the main hill the dip is to the N. E. with an angle between 20° and 30°. This does not, however, prevent the section of the little hill near Weean being a very good one for study. We shall proceed from E. to W.

1. Impure arenaceous limestone with fine spangles of mica. It is very shaly in the centre of the bed and there very much decayed. It changes its aspect repeatedly, adding here more sand and mica, there more clay, ... 100 ft.
2. Limestone, argillaceous; in blue and yellow patches,............ 4 ft.
3. Blue limestone, weathering brown and rough. It is arenaceous near its upper part. It contains a very few fragments of fossils, ... 20 ft.
4. Finely crystalline limestone; nearly saccharine; grey and rough,.. 15 ft.
5. Like 3,.. 8 ft.
6. Limestone in blue and dirty yellow patches; fossils much broken, ... 12 ft.
7. Flesh colour limestone; hard, cherty and magnesian, ... 4 ft.
8. Sandstone, micaceous, grey, calcareous and muddy. It decays faster than the other beds and forms a depression on the hill-side, ... 2 ft.
9. Limestone, patchy blue and brown. The hardest and roughest portions are full of the debris of fossils, ... 25 ft.
10. Sandstone, soft and wearing off quickly, forming a depression 20 ft.
11. Limestone, hard and grey; it is brecciated and weathers mammilated, ... 30 ft.
12. Marly and sandy limestone, compact and hard, dark grey and weathering into a granular surface, having the appearance of a sandstone. The debris of fossils, ... 40 ft.
13. Fawn-coloured limestone, very muddy; it weathers ochrous and decays fast, forming a depression on the hill side,.......................... 15 ft.
14. A wall of very hard, crystalline, dark greyish-blue limestone with

patches coloured brown. It weathers a dirty dark yellow, and becomes extremely rough and pitted by exposure. The organisms it contains are quite indistinguishable, ... 3 ft.

15. Fawn-coloured limestone like 13, ... 20 ft.

16. A wall of very hard and compact limestone, grey and very arenaceous. Where it is tolerably free of sand, it is bluer and contains the debris of fossils, ... 15 ft.

17. Sandstone, pale and calcareous, with bands of crystalline carbonate of lime. *It decays fast and forms a depression,* .... 10 ft.

18. A well marked wall of dark greyish-blue limestone, very rough and pitted; it is arenaceous and in places cherty, ... 5 ft.

19. Sandstone, micaceous, very false-bedded and very muddy It effervesces with acid along the scum-markings of the false bedding only, ... 15 ft.

20. A very arenaceous and argillaceous limestone, *extremely variable* in its appearance, but being generally of a pale clayey yellow. It is formed of extremely thin layers of two distinct rocks, one being a yellow marl, and the other a bluish grey arenaceous limestone, and these thin layers are also very false-bedded. When we make a vertical section of a hand specimen, we have a striped rock; and in a horizontal one, a succession of regularly rounded patches of bluish grey and sickly yellow. This alternation of very thin and very false-bedded layers of rocks of two different colours is the cause of the patchy appearance of many beds of the Weean group. But it is rarely so well defined as in this present layer. In other places, the bluish limestone forms irregularly-rounded balls or nodules cemented together by the yellow marl, or the marl forms lumps imbedded in the limestone. Then again micaceous sand forms, here and there, small false-bedded layers or bands in the rock: and lenticular beds of a hard, brittle, pale yellowish, limestone, full of the fragments of bivalves and of small crinoid stems, are also found. But all these varieties of rock constitute a thick course of impure limestone, 60 ft.

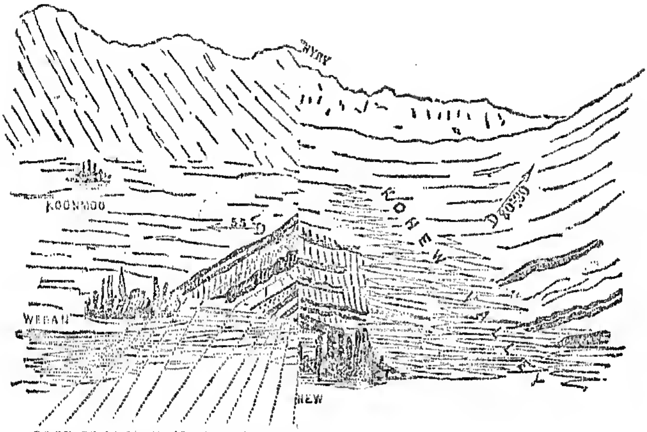
Total ... 425 ft.

We have now arrived at the little ravine which indicates the centre of the fold of the beds; on its other side the same beds are repeated in an inverse manner as far as the bed 16 of the above section; the remaining beds have been denuded from the western branch of the fold. This fold deserves notice, as showing well how completely beds may be reversed in their position. It is probable that the beds nearest to the ravine are the deepest or oldest, whilst the bed which we have numbered No. 1, in the section, is the most superficial. If the hill had been denuded to half its present height above the village, the beds

Sketch Section of the hills ·tains.   (Not drawn to scale.)

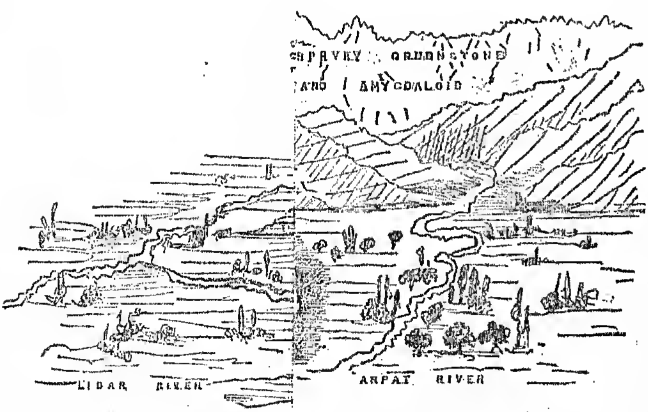
W.

Limestone hills, (Zeban



Sketch-Section of the Ha… Hill.   (Not drawn to scale.)

·538)



would appear to succeed one another with considerable regularity from W. to E., and one bed, No. 1, would appear the deepest; but the top of the hill having been preserved, the beds can be seen plainly bending and folding themselves in two. There is a circumstance which renders it extremely easy to follow the beds along the hill-side and it is this, that the layers 16, 17 and 18 form a sort of broad ribbon at their outcrop; 16 and 18 being composed of dark grey walls of limestone which, from their hardness, are prominent 2 or 3 feet over the general surface of the slope, whilst 17, the layer between them, is a pale sandstone, decaying fast and forming a sunken furrow between the two walls. This broad ribbon, about 30 feet wide, can be followed with the eye for miles. The layers 7, 8 and 9 also form a ribbon, but less well marked than the other, being paler and not so sharp. Now, these two ribbons are of the greatest assistance in following the twists and foldings of the beds. We have seen that the ribbon 16, 17 and 18 ascends the eastern branch of the fold over Weean and curves over at the top of the hill, where its beds are perfectly horizontal, and then descends along the western branch. We see the two ribbons forming near the village of Kohew an anticlinal similar to that of Weean, but not quite so sharp, and the description of the ribbon also shows us plainly that the beds of the Weean hillocks are reversed. There is a great fault between the main hill and these two little hillocks of Weean and Kohew; on the north of the fault, the beds dip to the N. E. at a high angle, and all the soft and marly layers have decayed and tumbled down in *éboulis*,* but the hard ribbon has remained, and can be traced along the hill showing the outcrop of the beds. All the way up to Nawan we can see the beds of limestone dipping N. E. and we can infer the existence of many faults across the range from the reappearance of the ribbon on the top of each small spur which descends in the Kohew valley. We see these pieces of ribbon plunge under the soil of this small valley to emerge on the other side (fig. 7), giving us the strike of the beds of that long chain of limestone hills which connects Nawan with the Wastarwan Mountain; but although I have

* The French word is so convenient and expressive, that I do not hesitate to use it, as no English word expresses equally well the broken materials of beds which have slipped.

not visited that long chain of hills, and have not travelled up the Kohew valley, I was enabled in following these ribbons, to see that it is composed of the variety of limestone which I have called the Weean Bed.

We shall observe these ribbons wherever the Weean limestone is well developed; they are to be seen in the section I have given, between Zeeawan and Koonmoo, on the southern aspect of the Zebanwan. I did not mention them there, because they make but little show near these localities; but we shall see them well marked near Mutton, in the eastern portion of the valley of Kashmir.

32. I will now try to characterise the Weean Bed of carboniferous limestone.

It is a very arenaceous and argillaceous limestone, the sand being either in thin grey bands, or mixed with the general paste of the rock. A sandy, marly clay, yellow, dirty-yellow, pale brown or brown, forms thin and very false-bedded films in the rock, so that this is striped when bisected vertically, and patchy bluish and yellow when divided horizontally. The hardest beds are brittle, flesh-coloured and generally full of bright red minute crystals of hæmatite, and the fossils are here replaced by a powdery or semi-crystalline hæmatite which, however imperfectly, preserves their outlines. The harder rock is never blue, and the blue variety of rock is sufficiently muddy to have a soft, velvety, lustreless appearance like a fine clay, and not the clean brittle fracture of a pure and hard limestone. It has in places all the appearance of a very dirty dark-grey mud dried up, and it is then full of fossils and extremely fœtid. It contains lenticular beds of a very pale, nearly friable limestone, containing black specks which are the rings of stems of very minute crinoids, and this variety of soft limestone is the habitat of large bivalves. One single bed of limestone may be mistaken for Zeeawan limestone, bluish-grey, coarse hard and semi-crystalline, but it contains innumerable *Foraminiferæ* transformed into yellow ochre; very large *Pectens*, and an incredible quantity of fragmentary *Crinoidea*. Indeed, it is the great number of those small rings of crinoid stems, always crystallized, which causes the rock to resemble the limestone of the Zeeawan Bed.

Everything in the Weean bed tells of a shallow sea formation. The rocks in some localities, to be described hereafter, have been much altered by heat or other forces soon after their formation. We shall see them thus altered at Manus Bal and at Islamabad, and also at the Kafir Kote in the Punjab district of Bunnoo. It appears that considerable disturbances occurred while the Weean Bed was still in a soft state. But this subject will be examined more carefully in another paragraph of this paper.

The fossils differ a great deal from those of the Zeeawan Bed. In most layers they are mere debris hardly to be recognized. When they do occur, they are always crowded together in limited beds. The *Spiriferinæ* and *Terebratulæ* appear to have lived in shallow lagoons, in creeks in the sand, in pools on a flat marshy shore, and the large bivalves on sandbanks and shallows. The following fossils appear to be characteristic of the Weean Bed, as they are not found either in the Zeeawan Bed below or the Kothair bed above.

Spiriferina Stracheyii (Salter)?
,, *Stracheyii* (Salter)? var. *altior*, (Verch.).
Solenopsis imbricata? (Koninck).
Solenopsis sp. —— Pl. VI. fig. 1.
Cucullæa? sp. —— Pl. VI. fig. 4.
Anthracosia? (King)—*Cardinia*, sp. Pl. VI. fig. 3.
,, ? —— *Cardinia ovalis?* (Martin) Pl. VI. fig. 3.
Axinus, sp. n., allied to *A. obscurus*.
Aviculo-Pecten dissimilis (Fleming).
,, ,, sp. n. —— (*A. circularis*, Verchère,) Plat. VII. fig. 1, 1a, & 1b.
,, ,, sp. —— ? Pl. VI. fig. 6, 6a, 6b.
,, ,, sp. —— ? Pl. VI. fig. 7, 7a.
,, ,, sp. —— ? Pl. VI. fig. 7, 7a, 7b.
,, ,, sp. n. —— ? (*A. Testudo*, Verch.) Pl. VII. fig. 3, 3a.
,, ,, sp n.? (*A. Gibbosus*, Verch.) Pl. VII. fig. 4, 4a.
Goniatites, sp. —— like *G. Henslowii* (Sowerby).
Entomostracæ—*Cypridiniæ?*
Foraminiferæ.
Crinoidea; Cyathocrinites and *Pentremites*.

A small bivalve, giving on section the appearance of a pair of spectacles is also found, but I never could detect the shell entire, although it is often the only fossil to be discovered.

33. But to the positive evidence afforded by these fossils, we must add the negative evidence: I mean we must remember that this is a bed of carboniferous limestone, and that notwithstanding we have no examples of the genera *Productus*, *Orthis*, *Euomphalus Bellerophon*, and *Orthoceratites*, and that there are no large *Spiriferæ* or *Fenestellides*. Neither have we the *Gasteropods* and *Cyathophyllides* which characterise the uppermost or Kothair bed, more by their number and variety, than by any species well defined by me. I am anxious to insist on the absence in the Weean group of these fossils, which are generally regarded as eminently carboniferous, because it has been found difficult to determine the age of rocks belonging to the Weean bed, when seen apart from the Zeeawan Bed; thus the limestone of Manus Bal, which belongs to the Weean group, has been twice reported to be nummulitic.

34. The next mountain to examine is the Wastarwan. It is a fine hill, its summits rising above Avantipoor, a small city on the Jheelum celebrated for its Buddhist ruins. An inspection of the map will be better than any description I can give of the position and relations of this mountain. It is a centre of elevation, with spurs descending in all directions, like the spokes of a wheel. I never ascended it, but I travelled along its northern and its western sides, and the following is a description of what I saw.

Section from Reechpoora towards the E. as far as longitude 73° 5′. *across the northern spurs of the Wastarwan: (See Map C.)*

The spur which descends to near Reechpoora is entirely composed of Zeeawan limestone with the characteristic fossils. The bed forms a sharp anticlinal of which the two arms slope or dip N. E. and S. W. respectively, striking N. W. to S. E. The beds of limestone inwrap the end of the spur, the layers seen above the little Buddhist ruin dipping nearly due N. The anticlinal is so sharp that the courses of rock have separated, and caves, now converted into holy quarters for a few fakirs, are to be observed on both sides of the anticlinal.

35. Proceeding eastwards, after crossing the bed of a stream, we

observe near Banda, a small Zyarut up the ravine above Ladoo, some very fine beds of limestone of which the following is the section.

Proceeding from the bottom of the ravine up the side of the spur we find.

1. Slates, so much decayed and broken that it is impossible to see their dip and strike. They are identical with those which we have seen interbedded with volcanic ash and agglomerate in the Tukt-i-Suliman and the Zebanwan, and they are very extensively developed in the Wastarwan. They are, as we have seen, more or less metamorphosed, often slightly amygdaloidal and always devoid of organisms, ... very thick.

2. Augitic ash, very amygdaloidal, the geodes being filled sometimes with dark augite, sometimes with bluish-white opalescent quartz. It strikes N. W. by W. and dips north-easterly. About .... 25 ft.

3. Trachyte, sparingly amygdaloidal; coloured brown outside by iron, ... 10 ft.

4. Metamorphosed slate, foliated, jointed, disintegrating, ... 20 ft.

5. Compact basalt, ... 4 inches.

The debris of volcanic rocks form a breccia over the basalt; but this bed is very irregular and lenticular. The basalt is replaced in some places along the strike by a dull, light-olive-coloured laterite or baked clay, about one foot thick.

6. Quartzite, sometimes pure, opaque, white; often translucent, bluish or smoky; never crystalline. It gradually invades the laterite mentioned above, and forms ribands of dull olive and pure white quartz, ... 2 & 3 ft.

7. Zeeawan limestone with usual fossils; dips N. 15°, ... 40 ft.

8. Zeeawan brown shales, ... 10 ft.

9. Fine blue clay-slate; calcareous and breaking in large thin slates. It contains no fossils, ... 10 ft.

Extensive old quarries remain here, showing how fine and free a limestone the Zeeawan bed can give, when quarried in portions of rock which are not weathered. The quarries are far from exhausted, or rather the amount removed is insignificant compared to what remains; blocks of any size and very sound could now be procured easily from the old quarries. It is a great pity that the Maharajah's government do not work this and other quarries for the limestone they want, instead of destroying the interesting Buddhist ruins which cover the valley, especially as the style of architecture now in favour in Kashmir is perfectly hideous.

Traversing a ravine we meet the spur which descends towards the village of Mandikpal, and the following section is met with :

1. Amygdaloidal greenstone.
2. Amygdaloid.
3. Quartzite.
4. Rotten Augitic ash.

Some of the ground is covered with ths debris of the ash, so that its relation to the next bed is not seen.

5. Limestone, argillaceous, pale bluish-grey, weathering fawn-coloured : afterwards patchy blue and brownish. It is thin-bedded and breaks in slabs about one to one and a half inch thick. It contains an abundance of *Goniatites* of 2 or 3 species. The bed is about.. 30 ft.

The dip of these several layers of rock is N. N. E. 25°.

This is the only locality where I have seen Weean limestone resting immediately on volcanic rocks.

From Mandikpal, our section goes through a succession of limestone ridges which, from the appearance of the ribbons described at the hillocks over Weean and Kohew (para. 31), are conjectured to be Weean limestone, but I had not time to visit them. The general dip of their beds is north-easterly.

36. The western aspect of the Wastarwan I shall describe from S. to N., that is from Avantipoor to Reechpoora. It is a series of spurs with a general westwardly direction, and at the end of one of these spurs is a little knoll which I shall call for convenience sake the "Pampur knoll."

The following is the section of these spurs from S. to N. (see Map C.).

1. The whole of the spurs between Avantipoor and Tangur are composed entirely of volcanic rocks, *viz.*, amgydaloidal greenstone, coarse basalt and ash, and black slate without fossils. The limestone is first seen about three quarters of a mile south of Barus, where two spurs approach very near the river Jheelum.

2. As we ascend the most southern of these spurs, we find, resting conformably on dark amygdaloidal greenstone, a bed of white quartzite about 2 feet thick,.. 2 ft,

3. A coarse and rough trachyte,.. 12 ft.

A fault N. N. E.—S. S. W. It opens towards the northern end, whilst the edges of it are crushed one against the other at its southern extremity. On the northern side of the fault we find :—

1. Quartzite, bluish grey, gritty and rough, ... 2 ft.

2. Trap, having a shaly appearance. A great deal of kunkur is seen along the line of fault, ... 1 ft.

3. Quartzite, excessively irregular and having a very peculiar appearance: it is divided in meshes like a very coarse travertin, or rather like lead which has been dropped in cold water while in a melted state. There is however a certain pretty well marked stratification or superposition of courses. The rock looks like a siliceous paste which had solidified suddenly when in a sate of ebullition. It first dips W. about 50°, increasing gradually to the vertical and then inclining the other way, dipping S. E. 80°. It, however, soon becomes vertical and gradually dips again W. 50°,........................ 40 ft.

4. Pale trachyte. Dips W. 50°, ... 15 ft.

5. Limestone, crystalline and metamorphosed; no organisms. Weathering rough; much stained by iron-oxyde,........................ 3 ft.

6. Zeeawan limestone with the usual fossils; dips W. 40°, ... 50 ft.

7. Zeeawan brown shales,........................ 10 ft.

8. Slate; coarse, micaceous. Squeezed by proximity to a fault; no fossils?

A fault, from N. E.—S. W. with a downthrow or the southern side. The slates are partially in the fault.

37. If we ascend the next spur, Barus spur, from the south, pretty high up the little ravine, and make our way to the monumental "Ling" which crowns the hill,* we see nothing but trap and ashes which have been brought up again on the northern side of the fault. The top of the hill is covered with grass and debris which prevent the rocks being seen in situ, but many pieces of ash, amygdaloid and white quartzite are seen loose on the earth, showing that the usual quartzite bed exists here. On the western and north-western aspect of the hillock, the rocks are uncovered and we have the following series.

Trap and volcanic ash........................

Quartzite ....

Here two beds are covered by vegetable earth, as mentioned above.

1. Zeeawan limestone with usual fossils. Dips W. 50°,........... 40 ft.

2. Greyish-blue limestone without fossils,........................ 15 ft.

3. Beds concealed by vegetable earth and by lacustrine deposits 30 ft.

4. Shaly limestone with few and broken shells........................ 40 ft.

* This is, I believe, one of the largest, if not the largest "Ling" or "Emblem of Creation." It measures 14 feet in circumference and was about 20 feet high. The base is hexagonal; the preputial line is in relief, and appears to have been carved. This monster ling is now broken in two or three pieces, and the upper half is prostrate on the ground; the hexagonal base and about 6 feet of the body of the ling are still standing.

5. Limestone, very impure and containing immense numbers of a Spirifer of large size, very similar to *Spirifera Verchèri*, De Verneuil Pl. I. (fig. 1a. 1b. 4 ft.

6. Limestone with a few fossils, ... 30 ft.

7. Limestone, filled with *Productus costatus* (S.W.) often extremely depressed by pressure. Many other fossils associated with the *Productus*, such as *Athyris Spirifera*, and a species of *Chonetes*, &c. The limestone is arenaceous and micaceous, often so much so that it passes into a calcareous sandstone. This passes gradually into the next bed, the fossils becoming less frequent and the rock less sandy.

8. Shaly limestone. The beds 7 and 8 are together about, ... 60 ft.

All these beds are evidently, from their fossils, members of the Zeeawan group. The series is continued by beds of the Weean limestone.

9. Sandstone, grey, then pale brown. It contains lenticular beds of limestone. The bed is much disintegrated and overgrown with grass *Goniatites*,.. ?

10. Flinty-looking, shining limestone of a bluish grey colour. Divided by pastings of shale, thin and irregular. It weathers rugose and contains no fossils, ... 15 ft.

11. Calcareous slate, thin-bedded and exfoliating, ... 1 ft.

12. Flinty limestone like 10, ... 3 ft.

A lacustrine deposit covers any further bed which may exist.

The total thickness of this section is about 260 feet. The Zeeawan bed is nowhere so thick as it is here, being about 220 feet thick from stratum 1 to 8.

The remainder of the section is Weean limestone, but only partially seen here.

38. The end of the spur, immediatly north of Barus, presents also some Zeeawan limestone, but it was not examined. The two following spurs are entirely composed of volcanic ash and agglomerate.

39. Then comes the long spur which ends in the somewhat detached hillock which I have called the Pampur knoll. We find in this spur the beds we have just seen above Barus, precisely in the same position and relation. The similarity is so complete that it is evident that the Barus beds once extended to the Pampur knoll without a break, but that a great portion of this limestone has been denuded.

The volcanic rocks, in the long spur, are well stratified and rather thin-bedded as they approach the limestone. They dip W. N. W. with an angle of about 45°. The Zeeawan bed rests on quartzite

and presents the same beds full of the gregarious fossil *Spirifera trigonalis (?)* and of *Productus Costatus :* the distance between these beds is the same as it is at Barns. On the top of the Zeeawan beds are seen Weean beds, but they are much more complete than at Barns, having a thickness, from the top of the Zeeawan bed to the foot of the knoll, of about 660 feet. But I believe there are probably some faults which cause beds to be repeated, and that the Weean bed is not quite so thick; about 500 feet.

The Pampur knoll gives the following approximate section from east to west.

1. Coarse grey limestone.
2. Slaty grey limestone.
3. Patchy blue and yellow or pale brown limestone.
4. Compact blue limestone, argillaceous.
5. Patchy blue and dirty yellow.

These beds are together about 100 feet thick. They dip W. with an angle of 60°.

6. Flesh-coloured limestone.
7. Shaly coarse blue limestone.
8. Flesh-coloured limestone.

These 3 beds are together about 80 feet. Dip as above.

Other layers are buried under lacustrine deposits. This little hillock was examined very superficially, owing to want of time. No fossils were seen except the small broken bivalves mentioned above, and which are so common in all the rocks of the Weean group.

40. The spur seen half way between the Pampur knoll and Reechpoora, is tipped with Zeeawan limestone, but was not examined in detail.

41. Here ends our survey of the Wastarwan. I need not say that the central ridges and summits are entirely composed of volcanic accumulations. Black basaltic rocks are abundant, and by their disintegration, and the rearrangement by water of the black mud they gave in decaying, a great quantity of black slate was formed which is seen interbedded with beds of ash and agglomerate. These volcanic rocks do not require to be described, as they are identical with those of the Zebanwan Mountain. All the rocks of the Wastarwan present a stratification or superposition; on the northern slope it

has a general dip to the N. E., whilst on the western aspect of the hill its dip is generally westerly. There is therefore a sort of anticlinal towards the centre of the hill, following a direction from the N. W. to the S. E. We have seen how this anticlinal affects the limestone at Reechpoora, a locality which happens to be at the end of it.

42. The next mountain we meet, travelling towards the S. E. along the banks of the Jheelum, is the Kamlawan (8601) which terminates over the village of Murhamma. The mountain is composed, like the Zebanwan and the Wastarwan, of volcanic rocks. Melted rocks predominate in the centre of the system, whilst ash and laterite compose, in a great part, the most extended spurs. Slate is intermixed with the beds of volcanic cinders, and over these carboniferous limestone rests conformably. But the limestone of the Kamlawan appears to have been extensively denuded, and is only found in a small bed which makes but little show. The following is a section of the spur immediately over Murhamma. Direction of the spur N.—S. Strike E. S. E.—W. N. W.; dip S. S. W. (See Pl. 11. Section D.)

1. Trachy-dolerite, coarse and dark, here and there amygdaloidal; it has large joints regularly disposed, at right angles to the stratification and yawning, giving it a somewhat columnar aspect. This bed appears to extend from the top of the hill, to the beginning of the spur now under consideration. It is of very great thickness, and, making allowance for faults, it cannot be less than 2000 feet.

2. Baked clay-stone or compact laterite, grey, smooth, much jointed; it dips S. S. W. 70°. It has a thickness of about .... 200 ft.

3. Limestone, crystalline, coarse and metamorphosed. It contains a few fragments of fossils, not recognizable and mostly transformed into spar, 3 ft.

A fault, ...

4. Grey laterite or baked clay, like No. 2,.............................. 200 ft.

5. Amygdaloid, ... 20 ft.

6. Sandstone, or perhaps volcanic dust-stone; no fossils, ... 5 ft.

7. Coarse grit of rounded grains.

8. Basalt, fine and dark brown. The beds 7 and 8 are together 150 ft.

9. Sandstone or duststone, like 6, ... 5 ft.

10. Beds covered with grass and earth. Pieces of white quartzite and rotten ash seen amongst the grass, ... 100 ft.

11. Limestone of the Zeeawan group with *Productidæ*, *Fenestellidæ*,

Orthidæ, etc. It is much fractured and fissured, and is evidently but the remnant of larger beds removed by denudation. It dips S. S. W. 50° and it is about,.. 25 ft.

Any further beds which may exist are covered by the lacustrine deposit, which is here 150 feet above the level of the Jheelum.

The Sheri Bal is a small mountain close to the Kamlawan, to which it is united by a connecting ridge. It is entirely composed of the same semi-columnar trachy-dolerite which forms the bulk of the Kamlawan. The compact, smooth, grey, laterite or baked claystone, described in the section as No. 2 and 4, is seen extending on the flank of the hill, both to the west and to the east. It forms a conspicuous belt along the side of the Sheri Bal, appearing, from the high angle of its dip, to rest against the trachy-dolerite. Some of the volcanic and azoic rocks, described in the section of the Kamlawan as superior to the laterite, were seen on the slopes of the Sheri Bal, but no limestone was observed, it having probably been denuded.

43. Crossing the valley of the Lidar River, we find the next mountains to be the Hapatikri and Saijnarh group. The whole of this system of hills appears to be composed of limestone. It is continued to the S. W. by a low ridge, which is mostly buried under lacustrine deposits, but rises above these at Islamabad, forming a small hill at the foot of which the town is built.

The following section (fig. 8) will, I hope, give a good idea of the rocks composing these hills. The section is above the celebrated Tank of Mutton, near which locality the lacustrine deposit is about 120 feet thick. Above the lacustrine we find:

1. A limestone, coarse arenaceous and apparently much metamorphosed. It contains hardly any trace of fossils, excepting very crystalline rounded bodies which are altered stems of crinoids. The rock is divided into sub-beds by shaly or clayey partings, which are very false-bedded and very hard. Only a few feet of this rock appear above the lacustrine.

2. Limestone, jointed and cleaved; but hard specimens have a remarkably compact, smooth appearance, like hornstone.

These 2 beds dip E. N. E. 20°.

3. The bed No. 2 becomes gradually bluer and more argillaceous and less cleaved; towards the top of the bed it is the patchy blue and brownish rock which we have seen before repeatedly. It contains traces of fossils, but no shells sufficiently well preserved to be recognized. It has an enormous thick-

ness, varying however a good deal in places. There are remains of a Buddhist quarry in this bed.

The three beds have together a thickness of about .... 200 ft.

4. White and friable sandstone, apparently a compressed quartzose sand without cement. It dips N. E. by E. 25°. It contains traces of fossils. It is remarkably well seen near the Karaise or Irrigation Canal which is cut on the flank of the hill.* It is a thin bed and presents variations of color and aspect. It is only one and half foot thick, ... 1½ ft.

5. Argillaceous blue limestone, ... 2 ft.

6. Yellow sandstone, calcareous, not very hard, much disturbed and faulted, the faults, which are small and short, being at right angles to the strike. The sandstone has a thickness of about .... 10 ft.

In this sandstone, which, by the bye, does occasionally pass into lenticular patches of impure arenaceous limestone, a great many sections or outlines of large bivalves and some small ones were seen; but no shell in a tolerable state of perfection could be obtained; I, however, made drawings of the outlines presented by these bivalves, on the weathered flank of the rock. When I first saw these outlines, I did not know of the large *Anthracosiæ*, *Pectens* and *Aviculo-pectens* which exist in the Weean group, and it appeared poor and ungrateful work to copy them. Soon after, however, I found the *Aviculo-pectens* and other bivalves represented at Pl. VI. fig. 3, and Pl. VII. fig. 4, 4a, and my sketches of the sections came in very opportunely, proving, in the absence of better fossil evidence, the Weean nature of the Hapatikri limestone.

7. Very hard and brilliant white quartzose sandstone, ... 10 ft.

8. Sandstone, yellow and soft, like 6,.. 5 ft.

These sandstone beds are remarkably wavy and undulated, as if they had suffered from lateral pressure. The limestone above and below participates but very triflingly in these undulations.

9. Sandy limestone, blue and compact. The debris of small fossils, 10 ft.

10. Dark shales, slightly carbonaceous. In this bed, casts of roots of trees with a concentric arrangement and, in rare cases, the vegetable cells filled with coal, were seen. The roots are generally thoroughly petrified; they are numerous and mostly horizontally (to dip) arranged; they are branching and have generally a starry disposition like Stigmaria. Some pieces of these

* This canal was apparently intended to bring some of the waters of the Lidar to the Martand plateau; but it was never finished, and it is now falling into ruin. It is said to have been begun during the reign of the Mogul Emperors of Delhi; it is a work of considerable extent.

roots show a sort of epidermis, somewhat scaly like Lepidodendron. Large trunks were not seen. The bed is very thin, only $1\frac{1}{2}$ foot, and is covered by a bed of limestone 25 feet thick. It appears therefore probable that, owing to littoral oscillations, the vegetable covering of the shale was denuded during the progress of the sinking of the coast and previous to the deposit of the limestone, ... 1 & ½ ft.

11. Argillaceous limestone, compact and weathering white. Shaly partings, ... 25 ft.

12. Calcareous sandstone, of a compact structure and a dark blue color when fresh, but weathering reddish in an irregular and patchy manner, the redder patches being due to shaly masses which are seen here and there imbedded in the sandstone: these shaly masses sometimes form lenticular thin beds, as thin-bedded as sheets of paper. No fossils, ... 10 ft.

13. Grey limestone; no fossils, ... 6 ft.

14. Limestone, patchy blue and pale brown, ... 15 ft.

These two beds of limestone are not quite conformable to the sandstone and preceding beds; they are nearly horizontal, with a trifling dip of about 3° to the E. N. E. This is probably due to littoral oscillations or earthquakes.

15. Sandstones, greyish-brown and pale, ... 2 ft.

16. Limestone, ... 4 ft.

17. Very arenaceous, grey limestone, weathering a deep yellowish grey; it shows no organisms. It dips E. N. E. 20°. It does not appear to participate at all in the faults and folds noted before. It has resisted atmospheric influence well and forms a prominent and striking wall near the top of the hill. It is about .... 20 ft.

18. Pale blue sandstone, marly and shaly, weathering greyish-brown and patchy. It decays fast into a yellow sandy marl and forms a furrow at its outcrop,.. 15 ft.

19. Compact limestone, very hard and cherty. It is fawn-coloured, but sometimes greenish blue. It contains no fossils, ... 5 ft.

These three beds, 17, 18 and 19, form at their outcrop a ribbon similar to those described at Weean. Another ribbon is formed by the layers 14, 15 and 16, which appear to be the equivalent of the ribbon 7, 8, 9 at Weean. (?)

20. Sandstone, brown, hard and micaceous, ... 2 ft.

21. Limestone in blue and brown patches, ... 4 ft.

22. Sandstone, shaly and much fissured. Color grey or brownish-grey. It is hard, cherty and calcareous. It has a slaty cleavage, cutting the stratification obliquely by striking W. E. and dipping N. with an angle of 60°. It contains a few fossils. This bed varies a great deal, being sometimes a pure enough sandstone, at other times a sandy shale, and again a coarse sandy slate. It goes to the top of the cliff.. 20 ft.

This section gives a thickness of Weean limestone and calcareous sandstone, of 360 feet.

When I ascended the Hapatikri, I unfortunatly did so above Mutton, and only carried my section as far as the top of the hill at that place, that is as far as layer 22. A little swelling of the surface concealed from me the summits to my right, and I thought that layer 22 was the highest of the hill. From the top of the Islamabad hill, about four miles to the S. W., I could see, while sketching fig. 8, that the summit of the Hapatikri is considerably above the layer 22. Two dark layers or ribbons are well seen near the highest summit of the Hapatikri, and it is not impossible that some faults bring up again the same beds. It is, however, probable that some beds of the uppermost or Kothair Bed exist near the summit of the hill, as I found amongst *éboulis* and lose stones near Martand some corals, which are, I believe, highly characteristic of the Kothair bed. (Pl. VIII. fig. 4, 4a.)

44. The Sketch-Section (fig. 8) shows that all the ridges of the Saijnarh are well and regularly stratified limestone and calcareous sandstones ; I did not, however, visit these spurs. Behind the Saijnarh and the Hapatikri are seen the rugged volcanic mountains which bound Kashmir on the east, separating the waters of the Jheelum from those of the Chenab. The Arpat river brings down boulders from these mountains, and the lacustrine conglomerates, which are so extensively developed at the point where the Arpat and other streams leave the mountainous gorges to emerge in the open valley, give us a good idea of the composition of these mountains. All the boulders and pebbles, both of the bed of the river and of the conglomerates, are volcanic rocks, of which many varieties of amygdaloid are the most frequent. I never saw a single pebble of granite, syenite or gneiss, but quartzite is common, as well as limestone. That the pebbles and boulders of the conglomerate have been brought down directly from these mountains by torrents and rivers, and have not been drifted to where they are by the waves of the ancient great lake of Kashmir,* is

* The valley of Kashmir has been a huge lake since the appearance of man in the Himalaya. It is probable that a lake filling up the whole of the valley existed before that period, and that it was drained or tapped by some cause or another, allowing the valley of Kashmir to dry up nearly to the same

sufficiently proved by the shape of the boulders, these being rounded and ovoid in form, and not worn into the flat lenticular stones which are found on the beach of lakes, and which are so much appreciated by persons fond of making "ducks and drakes in the water."

45. I have said before that a spur of the Hapatikri extends to Islamabad, concealed under the lacustrine plateau (see fig. 8,) for a few miles, but appearing as a small hill over the town. The following is a section of this Islamabad Hill, from the S. W. to the N. E., beginning with the lowest strata exposed to view. The general dip of the beds of this hill is N. Easterly.

1. Marly limestone; bright blue; debris of fossils,.............. 15 ft.
2. Ditto ditto; white; no fossils, ... 20 ft.
3. Ditto ditto; grey; often reddish. Enormous number of *Foraminiferæ* forming ochrous bands in the rock, ... 1 ft.
4. Arenaceous, dark grey limestone, divided by partings of shaly pale-yellow limestone, very false-bedded and very thin. Rich in the debris of fossils, but very few in a good state of preservation, ... 25 ft.

These four beds dip N. E. 15°.

5. Limestone having a slaty cleavage and joints, white or pale grey, cherty in appearance, Fossils very numerous, but in comminuted fragments, 10 ft.
6. Marly, yellow, limestone. It is often flesh-coloured, and then shaly in appearance and weathering with a rough pitted surface,............... 2 ft.
7. Limestone like 4; full of the debris of fossils,..................... 1 ft.
8. Limestone, brown and cherty; debris of fossils,................. 1½ ft.
9. Very pale blue limestone, often white; very hard and rough; weathers rugose like frosted glass. Thin and false-bedded; fragmentary shells, 15 ft.
10. Sandstone; yellowish white or greyish-white, ... 6 inches
11. Coarse, gritty limestone, full of the debris of fossils; great abundance of *Foraminiferæ*, crinoid stems, *Fusus* (?) and fragments of a small bivalve, ... 3 ft.
12. Marly, dark grey-blue limestone; slaty cleavage, ... 3 ft.

extent as it is now, and that the valley then became populated. The lakes, however, began to fill up again, and the whole of the valley was again converted into one immense lake. This in its turn was tapped and drained to its present state. The earthquake, which broke up the barrier or dam at Baramoola, is reported by tradition to have been the beneficient act of the Hindoo god Kashyapa. The Mahomedans, however, say that it is Kashaf, Solomon's minister, who performed the wonderful work, and it is very probable that both Hindoo and Musulmans borrowed the tradition from earlier inhabitants.

I hope to be able to prepare before long a paper "On the Lacustrine deposits of Kashmir," in which the proofs of two successive lakes having existed will be given in detail. See also my note to para 9, page 100.

13. Marly limestone, deep blue in colour, cherty in appearance and weathering rugose; it is compact and contains no fossils,........................ 15 ft.

14. A portion of 13, in a brecciated state, ... 2 ft.

15. Same as 13,.. 12 ft.

16. Limestone similar to No. 2, ... 2 ft.

17. Foraminiferous limestone, similar to No. 3, ... 8 inches

This limestone contains many small yellow rounded bodies, mixed with the *Foraminiferæ* and appearing to have no organisation. They are perhaps excretions of mollusks. Also large patches of white, dotted, chalky, limestone which are, I believe, the remains of decomposed fossils of considerable size.

18. Argillaceous, pale grey, nearly white limestone. It gets coarse towards the top of the bed, and the uppermost layer is brecciated, ... 10 ft.

19. Indurated clay, ... 1 ft.

20. Limestone varying in colour, being white, yellow, flesh-coloured, grey or pale lustreless blue. It is very argillaceous, occasionally sandy. The debris of fossils mostly encrinite-stems, ... 10 ft.

21. Calcareous brown sandstone; no fossils, ... 4 ft.

22. Shales, hard and without fossils. These shales are in places, fine, silty and foliated; in other places sandy, coarse and thicker bedded, 10 ft.

23. Sandstone like 21, ... 5 ft.

24. Shales like 22, ... 10 ft.

25. A repetition of the beds 22, 23 and 24; but the materials are generally coarser, the shales never being fine and thin-bedded, but rough and thick-bedded; and the sandstone contains so much lime that it passes in some places into a very arenaceous limestone. It contains but little of the debris of fossils, but shows some flat impressions like those of large flat *Algæ*. These impressions are, however, ill-defined and could not be identified, ... 25 ft.

26. Pale but bright blue limestone; very argillaceous and interbedded with thin films of yellow silt,.. 10 ft.

27. A second repetition of the beds 22, 23 and 24. A few shells, but no imprints of algæ. It becomes gradually a coarse sandy limestone, and at the top of the bed it is an argillaceous and arenaceous limestone, pale blue or rather French-grey, weathering rugose like frosted glass and containing a very few fragments of shells only, ... 25 ft.

These three beds, 25, 26 and 27, seem to resist the influence of exposure better than the rocks above and below them, and they form at their outcrop a well defined ribbon; this, owing to the trifling angle of the dip, appears on the hill-side as a cliff which faces the city of Islamabad a little more than half way up the hill. These beds are slightly wavy along the strike, as if they had been pressed laterally. These undulations occasion trifling discrepancies in the dips taken in different parts of the hill. Along the line of our section, the cliff formed by the beds 25, 26 and 27 has a strike N. N. W.—S. S. E. and a dip E. N. E. 15°.

28. Limestone, patchy blue and yellow; argillaceous, ... 20 ft.

29. Limestone, very argillaceous and having a pure lustreless grey colour, and being striped on section, owing to bands of a lighter colour. The rock is so compact and fine-grained that it resembles a fine greenstone in structure. It is traversed by bands of rougher stone and also by bands of blue limestone. It weathers rugose and pitted,.. 20 ft.

30. Limestone like 28, ... 20 ft.

31. Limestone like 29, ... 15 ft.

32. Limestone, as white as chalk, but hard. It is full of geodes like an amygdaloid, the geodes being filled or lined with minute crystals of spar. The rock weathers in rounded bosses like granite or trap. It appears to have suffered a metamorphosis. It is probable that the calcareous mud which originally composed it was thrown into a bubbling condition by the infiltration of heated vapours or the immersion of hot volcanic products into a shallow sea. It presents no fossils or traces of fossils. The bed is not lenticular, but extends regularly along the strike the whole length of the hill, being conformable to the other beds, ... 5 ft.

33. Limestone similar to 31, ... 5 ft.

34. Marly, dark bluish grey and rough limestone, ... 5 ft.

35. Like 33 again .... 15 ft.

36. Hard and cherty limestone, pale grey or flesh-coloured. It contains a few geodes like No. 32. It weathers pitted and rugose; no fossils (?) .... 2 ft.

37. Limestone like 34, ... 5 ft.

The last three beds are a good deal denuded, owing to their being at the top of the hill, which is narrow and barren.

46. There can be no doubt of the Islamabad hill being composed of Weean limestone; the argillaceous and arenaceous condition of the rocks is exactly what we have seen in other localities where this sort of limestone is developed. The fossils are very unsatisfactory, being extremely comminuted. I have found, however, one *Spirifera* and one *Athyris* which are to be seen in the beds at Weean. I have seen also many sections and outlines of large bivalves (*Aviculo-pectens* and unio-like *Anthracosiæ*) similar to those found near Mutton. The *Foraminiferæ* are also extremely numerous, and the fossil shell which gives on the surface of rocks an outline resembling a small pair of spectacles, is very common amongst the debris of comminuted shells. The upper beds of the hill, from 29 upwards, contain no fossils and have a peculiar appear-

ance, suggestive of their having been baked, and they weather in rounded bosses like many volcanic rocks. I have suggested that their amygdaloidal condition and their "metamorphic weathering" may be accounted for by the hypothesis that hot ejecta of volcanoes, either hot water, steam, hot ashes or a current of lava, had found their way into a shallow sea and set it a-boiling. It might be said that these very impure calcareous muds might have had gases generated in their interior by the decomposition of organic matter or some other cause; but many layers which are much more fœtid and were therefore more likely to emit gases are not at all amygdaloidal, and besides, there is so much volcanic power manifested all over our tract of country, that it is more natural to invoke a little steam to boil mud with, than to look for less obvious hypotheses. But another reason in favour of volcanic metamorphism is, that these same white baked limestones have been observed in other localities, near Manus Bal in Kashmir and in the Kafir Koto mountain, in the Punjab, and in these localities they are disturbed by actions which appear to have taken place locally and to have affected these limestones much more than the rocks below them. The beds of Manus Bal will be described hereafter in these pages, and we shall be able to observe how faulted and twisted are the white limestones of that place. At the Kafir Kote there has been a similar local upheaval, and the disorder is very considerable. In this locality a felspathic sand, invaded by quartzite in tortuous branches, is the remains of the volcanic action which has taken place there, and the limestone, though much less marly than in Cashmir, is filled with geodes and veins of spar. I believe these actions to have been local and not very extensive; they had little effect on the Zecawan bed which had, by the time they took place, become tolerably consolidated, and they merely fractured and pushed aside the nearest portion of the bed; but they acted powerfully on the yet soft and muddy Weean bed, curving it and twisting it in all sorts of manners and directions; and when these folds and twists were again disturbed, probably intensified and placed in new positions by the final upheaval of the Himalaya, they became what we see them now, viz. most incomprehensible doublings and reversings of strata. Let us also remember the beds which I mentioned as having been seen from the brow of the last spur of the Zebanwan

visited by me; these beds were the top or near the top of the series of Weean limestone seen along the section of the southern aspect of the Zebanwan between Zeeawan and Koonmoo. I said, "From the brow of the last spur I have visited, a fine view is obtained of the next spur, and this is remarkable for a great twist of the strata which compose it. The limestone is extremely white, and resembles chalk-cliffs at a distance." Is it not highly probable that there again we had the same altered limestone? The beds were wonderfully twisted and folded, whilst those above and below them were hardly affected.

I consider, therefore, that these altered limestones are portions of the Weean group, and I believe that the alteration was produced by bursts of water at a very high temperature, or of gases hot and compressed; the eruptive power of these agents being sufficiently powerful to displace and uplift the calcareous mud of the sea-bottom, a mud which must have been plastic, from the great admixture of clay it contained, and which was covered by no great depth of water. It is for such an action, as I have supposed, that Mr. Dumont has proposed the term of "Geyserian" action, and for the rocks precipitated from these watery volcanoes (such as the felspathic sand with quartzite of the Kafir Kote) the name of Geyserian rocks. The name is sufficiently suggestive and requires no explanation. It is probable that the quartzite which we have seen placed between the volcanic rocks and the limestone, belongs to that class of rocks.

47. The Arpat river runs through a district named Kothair or Kotehar, and it is from this district that I have named the uppermost bed of the Carboniferous (?) limestone of Kashmir. We have seen a small patch of this bed near Koonmoo, in the Zebanwan, but we will find the bed well developed in the next hills we are about to visit.

A few miles to the S. E. of Islamabad is a mass of well-wooded and picturesque mountains which separates the valley of the Arpat river from the Nowboog valley. Arckbal, Tippoo, Karpur, Dhar and Nawkan are summits which appear to form the centre of a small system of hills; their height is between 8 and 9000 feet, and they deserve careful study. I was unfortunately not able to do more than pay the most superficial visit to Arckbal and the iron mines of Kothair; and the following are the notes taken during that visit.

The rocks which overhang the well-known Arekbal Garden, near the western foot of the hill, are a rough grey limestone similar to the grey coarse limestone seen on the Islamabad hill, (see No. 27 of the section of that hill), full of sand and other impurities. It dips W. by S. 52°. There appear to be beds of shales between the limestone courses, and these shales by their decomposition furnish the fertile soil on which grow the fine forests of those hills.

The foot of the Arekbal hill is therefore Weean limestone and shales.

I then proceeded to the small village of Kothair, on the eastern side of the Arekbal hill, in a small valley situated between it and Karpur. The rock of the spur of Arekbal, which extends towards Pahaloo, is a whitish or greyish limestone with very few fossils, and interbedded with beds of calcareous slate, apparently belonging also to the Weean group.

From Kothair, the path to the mines, crosses a couple of small spurs which have a direction S. to N. until we arrive at the ridge which unites Dhar and Tippoo and has a direction W. N. W.—E. S. E. The spurs above mentioned are composed of marly limestone, either lustreless and velvety pale blue or dark blue, weathering frosted. The beds are very badly seen, on account of the vegetation and humus. Where the limestone crops out, it seems to be dipping S. E. or E. S. E. with a very variable but considerable angle. The beds of limestone appear to be separated one from the other by thick beds of shales and slate. The limestone has exactly the appearance of that seen a little higher up, and which we shall see contains fossils characteristic of the Kothair bed; but I failed, however, to find organisms in the present beds.

48. The iron-ore is obtained from the sides of the main ridge between Dhar and Tippoo. The ridge presents many beds of very argillaceous limestone of a lustreless bright blue colour, dipping S. S. W. with an angle of 45°. This limestone is remarkable for the large number of gasteropods it contains; it is also rich in corals, especially of the *Cyathophyllidæ*, but the fossils appear generally as sections or outlines on the surface of the rock, and I could not obtain any of them whole.

Between the courses of limestone are beds of slaty shales of various colours, but generally dark grey, brown or reddish. The outcrop of these shales has disintegrated and decomposed into a vegetable earth of a dark red colour and covered by grass and underwood, and this earth has to be removed to bring the shales into view. In these shales the iron-ore is found as flat bands or ribbons of great tenacity and hardness, accompanied by softer ochrous clayey earth which is also used as an ore. The richest ore is the steel grey variety; this is not continuous as a regular bed, but forms bands or ribbons in the shale, sometimes thickening into a trunk a foot thick, at other times thinning into a flat ribbon a quarter of an inch thick.

The shales containing the iron-ore are about four feet thick, and are between beds of an arenaceous limestone which is blue and compact when freshly fractured, but weathers into a coarse, brown, nearly friable sandstone in the neighbourhood of the iron-shales. This change in the limestone (evidently produced by the infiltrating water becoming charged with peroxide of iron in its passage though the shale, and then acting as an acid on the limestone below the iron bed), is the indication sought after by the miners to dig an exploring hole; they dig above the altered limestone, and after removing a few feet of vegetable mould, discover the iron-ore in the upper part of the shaly bed. They make a hole just large enough to creep in and use a short miner's pick; the ore is difficult to detach, and, from the cramped position of the miner, the work is excessively laborious. The mines do not extend any distance under ground, and are generally abandoned in favour of a fresh hole, when artificial light is required to work.

From the examination of three or four of these small mines, I feel satisfied that the ore does not form a bed, but is arranged in a succession of ribbons and bands which run in the direction of the dip, sometimes anastomosing into a broad plane two or three feet across, sometimes thickening into a trunk or pocket, and sometimes dividing into thin and narrow ribbons which become lost in the shale.

The mines are all situated high up the hill (on this side of the ridge at least), within about 200 feet of the summit. The miner I had for a guide told me that no iron-ore is found lower down.

49. The ore is carried in kilters or baskets, carried on the back, by the means of shoulder-straps, to Kothair, a distance of two miles on a bad hill-path. It is not smelted nearer the mines, on account of the want of water; though it seems that it would be very much easier to bring up water for the miners, who only know of that element as a drink and therefore require but little of it, than to take the ore down to the village. The ore is broken into small fragments by children, and mixed with the ochrous earth and with coarsely powdered limestone. These materials are piled up in a small furnace about two feet high, with intervening beds of charcoal, and two hand bellows are used to create a blast; the smelting lasts about 12 hours, and the produce of a furnace is only a few seers. The heat is not sufficient to make the iron run; and it remains at the bottom of the furnace as a viscous mass, full of scoriæ, and very brittle when cold, with a tufaceous aspect. The slag is a black glass, compact, and much less scoriaceous than is customary. The iron is heated and beaten with hammers to refine it. It is short, probably from bad manufacture.

Two or three men and children and some women, all of one family, working as miners, carriers and smelters, turn out about two maunds of iron in the month from one furnace. There are only three furnaces at Kothair, giving a supply of six maunds of iron per mensem. There are similar mines at Loap and at Kookur Nag in the Bringh valley, on the southern side of the same mass of mountains. From the dip of the beds, it is probable that these works are in a much more favourable position than those of Kothair; they are said to be much more considerable; the ore is obtained in the same manner as at Kothair, and there are no regular mines. The ore is the same, according to my guide, a miner who had worked at Loap, but it is obtained much more easily and is found in thicker beds. Mr. Turner showed me some iron from Kookur Nag, and it appeared identical to the pig-iron of Kothair.

The turn-out I have given of the smelting at Kothair is not to be regarded as an indication of the richness of the mines. I believe that the miners only work the ore to pay their taxes to the Maharajah's government, and that their most usual occupation is to grow a little rice and Indian corn. I have no doubt that the amount of ore is

considerable, and that a large quantity of iron could be obtained by increasing the mines, and adopting better furnaces with a blast worked by water-power, windmill or horse-power; but the miners and other inhabitants of the villages take great care not to mention to the Maharajah's officials any valuable deposit of ore which may be worked with advantage; they pretend that the Maharajah takes away all the iron for his arsenal and pays nothing for it, and that, when a supply of any ore is discovered near a village, the inhabitants have to work it by corvées, so that the discovery of a vein of valuable mineral is a calamity to the people of the neighbourhood. But this is probably untrue in many ways: the iron they supply is, as I have said before, taken in lieu of taxes; the care with which many of the holes are concealed with rubbish and branches, induces me to believe that a good deal of iron is smelted in a contraband way; and last but not least, making a secret of mineral wealth is quite consistent with the love of hoarding riches so prevalent amongst natives. The same concealment of ores is now going on in Huzara, where a little iron is known to exist, and where the reason of the Kashmir miners would certainly not avail; and it is reported by the geological surveyors of the Ranigunj coal-field that it is impossible to believe negative reports from natives. In Kashmir, moreover, the Maharajah's government entertain the same childish fear, lest the mineral wealth of the country should become known, and I well remember with what silly recommendations of secrecy I was shown by one of the Maharajah's servants a small piece of iron pyrites of the most insignificant value.

50. The rocks we have described form the Kothair bed (of Carboniferous limestone?). They are a succession of courses of limestone, shales of a dark reddish or ochrous colour, dark slates and calcareous sandstones. I am sorry I cannot give a section, but the following remarks will, in a way, supply its want.

The limestones are of two descriptions, viz.: some coarse and very sandy, indeed so much so, that when the carbonate of lime is removed by water charged with peroxide of iron, a brownish sandstone is left; it contains no fossils, and passes gradually into a rough grey sandstone with a calcareous cement. The other variety of limestone is argillaceous, and passes into calcareous slate; it is dark blue or even

perfectly black when fresh-fractured, lustreless like a clay and with a strong earthy smell; it weathers much paler, becoming covered with an incrustation which is bright pale blue, yellowish or whitish; the surface being at first velvety or satin-like, and so fine-grained in some specimens, that drops of rain or of dew falling from grasses leave small blots or stains, which after a while becoming frosted. The fossils of this limestone are well brought out on the weathered surfaces, as outlines or sections which are slightly in relief. The shales when ochrous, are very sandy. sometimes calcareous, oftener not so; they contain beds of clay iron-stone in irregular and wavy tabular bands or ribbons of an iron black and bluish black colour, and also of yellow carbonate of lime, and iron in a more or less friable condition. These shales have a well-marked slaty cleavage cutting the strata at a right angle. The slate is black, thick and massive and contains no fossils. It often becomes pale green and unctuous, and is then very thin-bedded and exfoliating. The sandstone is composed of rounded grains of transparent glassy quartz which are brittle, and break across when the rock is fractured, and each broken grain reflects the light, so that the sandstone has somewhat the aspect of a micaceous sandstone.

The fauna of the Kothair bed is more remarkable for the abundance of certain animals than for any species that I can well define. *Gasteropoda*, generally small, and corals of the "*Cyathophyllidæ*" are nearly the only animals seen. A few bivalves, small and thin-shelled, also occur, but they are rare, compared to the quantity of gasteropods. A few roots and stems, generally small, have been observed in some beds, but could not be recognized.

The following fossils are the most usual in the Kothair bed.

Naticopsis ?
Macrochilus ?
Chemnitzia ?
Loxonema ?
Nerinæa ?
The fragments of *Gasteropoda* in great number.

Cyathophyllum ?	sp.	Pl. VIII. fig. 2.
„ ?	sp.	Pl. VIII. fig. 3.
„ ?	sp.	Pl. VIII. fig. 4.

It is evident that a list of fossils, such as is given here, is insufficient to determine the age of a bed. My calling the Kothair bed Carboniferous, is therefore only temporary, and it is possible, and indeed probable, that the bed is either Permian or Triassic. I have often felt inclined to regard it as Triassic; but the total absence of *Monotis*, *Ammonites* and other characteristic fossils prevents my doing so. I have therefore preferred to represent the Kothair bed as the top of the Carboniferous series, until some characteristic forms be discovered. The Kothair bed was examined much more superficially than the others, owing to want of time; yet it is worthy of notice that I have never heard of an ammonite having been found in the valley of Kashmir, though the mountains of Kothair limestone, at the extreme eastern end of the valley, are very often visited by tourists and amateur geologists.

51. The Kothair formation differs from the Zecawan and Weean by the great quantity of shales it contains, these being in thick strata between thin beds of limestone. The fauna is, I believe, strongly indicative of a low swampy shore bathed by a shallow brackish sea. The arrangement of the iron-ore is, I fancy, to be explained only by the hypothesis of a clayey shelving sea board: any one who has observed hot chalybeate springs issue from the earth, near a flat piece of ground, must have noticed the sluggish stream divide into rills and rillets, form shallow pools here and there, reunite and divide again, meandering over the clayey soil; he will have noticed the oxide of iron contained in the water precipitated along the rivulets and in the pools as a bright red peroxide, whilst the surface of the nearly stagnant water is covered by a many-coloured film. This, I would submit, is the very process by which the iron of the Kothair shales has been deposited on the flat muddy shore of the Carboniferous sea: the rills of chalybeate water have become the tabular ribbons of our iron-ore, and we have therefore the ironstone arranged as a main flat vein, or rather in somewhat parallel veins, with irregular small shoots on both sides, and occasionally a thickened and widened mass representing a pool or a hole in the bed of the stream. Many springs, such as I have described, exist now-a-days in the Salt Range, near the Kafir Kote hill, and in several localities in the Himalaya; the iron mud they deposit would, under favourable circumstances, and in the course of long years, form beds

similar to the iron-ore of Kothair; and when it is remembered how essentially volcanic the Carboniferous period has been, it is no great stretch of imagination to assume, that much of the iron contained in the rocks of that period was derived from hot chalybeate springs, rather than from decomposed minerals on the surface of the earth.

Here ends the description of the Kothair bed. No rocks superior to it (excepting lacustrine and alluvial deposits) were seen in Kashmir, and the Kothair bed appears the most superficial stratum existing there. In other localities, both in the Himalaya and in the Punjab, Secondary and Tertiary rocks cover in the Palæozoic beds, but neither Oolitic, Nummulitic nor Miocene are to be seen in Kashmir proper, that is, between the Pir Punjal and the Ser and Mer chains, and between the northern branch of the Kaj Nag and the chain connecting the Ser and Mer chain to the Kistwar mountains.

52. As far as I could learn, the whole of the hills, which fill up with their spurs the south-eastern end of the valley, are composed of carboniferous limestone; this appears to go as far as the foot of the range which separates Kashmir from Maroo and Kistwar, where the limestone rests on volcanic rocks. *Producti* have been found among éboulis close to the volcanic rock high up the slopes, and it is therefore probable that the Zeeawan bed reappears under the Weean and Kothair beds, as we near the volcanic rocks. The river Bringh, which drains all the S. E. and a good deal of the east of the valley, carries in its bed boulders of volcanic rocks and of carboniferous limestone. No granite was seen.

As I have not visited these hills and possess only little information on their geology, I will not enter here into any detail of what may be inferred from reports received by travellers who are not geologists, and I must refer the reader to the map for the probable position of the several rocks which compose these hills.

53. To the N. W. of Srinuggur there is one more mountain belonging to the same catenated chain of summits which we have described in this chapter; it is the Safapoor, with its outlier, the Aha Tung, and the beautiful little lake of Manus Bal at its foot. This locality is interesting, and I will describe it in detail. (See Sections E and F; Section IV. of General Map). The Safapoor and the Aha Tung are both composed of volcanic rocks exactly similar to those which we have seen at the Tukt-i-Suliman and the

Zebanwan. In the small valley or gap between the two hills are beds of limestone which I will now describe. (See Section E; and also Sketch-Section F.)

Proceeding from S. to N., we first find at the northern end of the Aha Tung a limestone quarry. The limestone is about 120 feet thick, and dips south with a very high angle. It appears to be covered by beds of greenstone confusely stratified; but on examining the bottom of the quarry, the courses of limestone are seen to bend towards the N., and the limestone is therefore superior to the trap. The diagram here given fig. 9, represents the position of the rocks. I am indebted to Captain Godwin-Austen of the Great Trigonometrical survey for calling my attention to this bend of the courses of limestone at the bottom of the quarry. If this curving of the limestone was not seen, it would be nevertheless easy to understand the true position of these beds, as they are precisely similar to those on the other side of the road (see Section), but in an inverse position: the rock nearest the greenstone is a glaring white and much altered limestone. It is succeeded by a dark, greyish, argillaceous limestone, weathering bluish and rugose. On the other side of the road, the dark limestone appears first, and underneath it the bed of glaring white altered limestone. There is therefore every evidence of a synclinal; but, of course, the discovery of the bend of the beds in the quarry completes the evidence very satisfactorily.

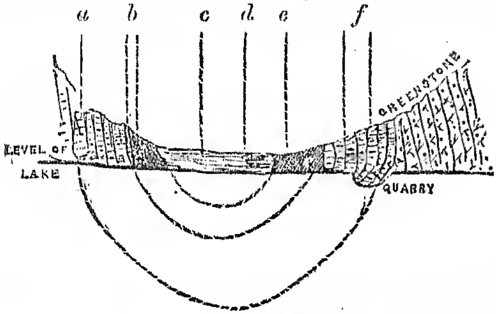


Fig. 9.*

Taking our Section from the S. to N., beginning at the road and leaving out the beds redressed against the Aha Tung which I have just described, we have the following strata :—

1 Greyish-blue limestone; marly, rugose, hard, dips S. 60°, increasing to 70°; much broken bed: about ... ... 20 ft. thick.

* *a* White Limestone. *b* Dark Limestone. *c* Alluvium. *d* Road. *e* Dark Limestone. *f* White Limestone.

2. Pale limestone, weathering glaring white; filled with geodes, lined with small spar-crystals. No fossils. Dips S. 80°, ... 100 ft.

3. Thin-bedded, shaly, striped limestone, ... 5 ft.

Fault. It runs E.—W. and is about 10 feet wide at the top. It is filled with rocks similar to No. 3, folded in all directions.

4. Limestone like 3; vertical, ... 15 ft.

5. Pale limestone; with geodes, like 2. Traces of fossils were observed, but much altered and not recognizable, ... 100 ft.

6. Pale blue, shaly limestone; dips N. 80°, ... 3 ft.

7. Like 5; dips N. 80°, ... 50 ft.

Fault; it runs E.—W.

8. Same as 7, ... 50 ft.

9. Argillaceous, thin-bedded, pale grey limestone, breaking in flat thin pieces, like pottery, ... 80 ft.

10. Sandy limestone, hard and dark, ... 20 ft.

11. Conglomerate limestone, varying from a coarse sandy limestone to a perfect conglomerate, the pebbles being rounded, pieces of limestone imbedded in a soft calcareous paste. It contains many sections of the *Aviculopectens* and other large bivalves peculiar to the Weean bed. Portions of the bed are white and altered, ... 100 ft.

12. Sandy, micaceous, limestone; dark grey, ... 2 ft.

13. White limestone; no fossils, ... 15 ft.

14. Argillaceous limestone, blue and pale; weathering lustreless and velvety, ... 5 ft.

15. Conglomeratic limestone like 11, ... 50 ft.

16. Brecciated and sandy limestone; sometimes a coarse calcareous sandstone, ... 5 ft.

17. Ash-blue, pale, muddy limestone; weathering lustreless, ... 25 ft.

18. Brecciated and sandy limestone, ... 12 ft.

19. Ash-blue, pale and muddy; weathering lustreless, ... 25 ft.

All these beds dip S. with an angle diminishing gradually from 80° to 35°.

20. This bed is the top of a well defined anticlinal. The rock is a yellowish-grey limestone, with rolled pieces of limestone imbedded. It is sandy, sometimes quite a sandstone, oftener a sandy impure limestone. It contains a great many remains of fossils. The southern branch of the anticlinal dips S. 35°; the northern branch dips N. N. W. 25°. There is therefore a squeezing of the strata at the western end of the strike, and a divergence or opening of the fault at the eastern end. Thickness about 30 feet.

Then we get a repetition of the beds seen before, as follows:

21. Ash-blue, lustreless muddy limestone, ... 25 ft.

22. Brecciated and sandy limestone, ... 12 ft.

23. Ash-blue limestone, ... 25 ft.

24. Brecciated limestone,... ... ... 5 ft.

25. Conglomeratic limestone, with sections of large bivalves, ... 50 ft.

26. Ash-blue, lustreless limestone, ... 5 ft.

27. White limestone, ... 15 ft.

28. Micaceous and sandy limestone; thin-bedded dark grey; dips N. N. W. 80°, ... 2 ft.

29. Conglomeratic limestone; gritty; in places a conglomerate, in others a breccia; dips N. N. W. 85° at first; then it becomes vertical and at last dips S. 80°, ... 100 ft.

30. Arenaceous limestone, dark, rough and forming a prominent ridge; it dips south 80°, ... 20 ft.

31. Thin-bedded, muddy limestone, breaking in pieces like pottery; dip irregular; bed folded and wavy, much disintegrated, ... 80 ft.

32. Shaly limestone, very impure; dips N. 80°.

33. Sandy limestone, dark and rough and hard; dips N. 70 to 75°. These two beds together are about, ... 30 ft.

34. Limestone, generally sandy and grey, but sometimes more compact and bluer, and then showing innumerable white lines crossing each other in all directions. It dips N. 70°, ... 100 ft.

35. These several varieties of limestone, viz. shaly and sandy, and blue with white lines, repeat themselves continually as far as the top of the hill, but the rock becomes more and more massive and presents portions of crinoid stems well preserved and petrified into a black spar. Sometimes the rock is flesh-coloured, and then the crinoid stems are lighter in colour, and weather in relief on the surface of the rock. These are the sections of crinoid stems which have been taken for nummulites by Mr. Vigne and Dr. A. Fleming. 150 ft.

The strike of the beds of limestone wheels more and more to a N. to S. direction. As we approach the volcanic rocks of the Safapoor, the dip becoming more and more westerly. This wheeling of the strike is well shown by the Sketch-Section (Sect. F), where we see the face of the limestone-courses uncovered and exposed, and facing the W. N. W. The thickness of the Weean bed is altogether 649 ft.

A large fault, well marked by a deep ravine, separates the limestone from the volcanic rocks. It runs N. E.—S. W. At the highest point the limestone is seen to attain, the fault is a mere crack, and the limestone is in contact with the volcanic rocks; but at the S. W. end of the fault, it widens considerably, and beds of limestone are to be observed on its northern side, applied against the trap and conformable and superior to it. The trap dips S. S. E.

On the western face of the Safapoor, long beds of well-stratified laterite and ash are conspicuous; they dip S. with an angle of 40.

54. Our section runs through the spur of limestone nearest to the lake; three other spurs, parallel to it, descend towards the village of Paturmoola (see Section F.). They present very won-

derful twists and foldings, but appear less altered than the beds which are bathed by the lake; their fossils are better preserved. I have not ascended these spurs, but amongst the *éboulis*, I saw many fossils characteristic of the Wecan limestone, amongst others large *Aviculo-pectens* and *Anthracosiæ*, of which sections only had been discovered in the rocks in situ.

Some blocks of limestone were also found exhibiting *Gasteropoda*, so conspicuous in the Kothair bed, and it is therefore evident that this bed forms the uppermost layers of the limestone of the higher spurs. I need hardly say, that the beds of Manus Bal belong to the Wecan group, and that they have been folded and altered in part by volcanic action, subsequent to the formation of the volcanic rocks on which they rest. The order of the beds is from the anticlinal upwards on both sides of it, and the rocks nearest to the trap are the most superficial, excepting, however, the detached beds which are conformable to the volcanic rocks on the northern side of the great fault. If the limestone had been baked by the amgydaloid and the greenstone, we would naturally expect to find the beds nearest to these rocks most altered; the reverse is however the case; and we must therefore admit that a burst of hot gases or hot water had taken place at the time these limestones were still a soft and plastic mud, and that it upheaved, folded and metamorphosed them.

It must not be forgotten, that the limestone might have been much less folded by this first disturbing action than we see it now, when the last upheaval of the Himalaya took place: the beds then slightly folded would naturally give way in the same direction as they were already bent, especially if the space they occupied between two unyielding trappean hills had become so restricted that the limestone must of necessity either be folded or override the trap. On the application of such lateral pressure, a straight, *flat*, hard bed might have slided over the trap, but a bed already undulating would more naturally give way at the weakest parts, viz. the angles of the undulations, and thus become gathered in crumpling folds. Such folds are well shown in the Sketch-Section, (plate F).

55. Having terminated our examination of the several mountains which form the first catenated chain on the N. E. of the valley of Kashmir, we can now understand how this chain was once conti-

nuous, the several summits being re-united to one another by ridges of stratified ash, agglomerate and limestone. These connecting ridges have been denuded by the several streams which flow towards the bottom of the valley, and the limestone is now found only in limited beds, which have escaped denudation from the shelter they received of large and hard volcanic mountains. These streams and rivers, it is hardly necessary to mention, have had a volume very different from what we see now-a-days; the enormous layers of lacustrine conglomerate, which they have accumulated near their entrances into the valley, demonstrate plainly their former great denudating power. The direction of these streams being from the high mountains in the N. E., to the bottom of the valley in the S. W., they have cut for themselves channels which are directed from N. E.—S. W., and thus bands of the ridges, which united the summits of our first chain to those of the second chain, have remained between the channels of these streams, and given to those mountains the appearance of being long spurs descending from the N. E. to the S. W.

56. I shall, I hope, best terminate these detailed Sections, by appending a table of the fossiliferous and other rocks in Kashmir, together with such observations as the nature of the rocks or the fauna best justify.

Formation	Masses, Beds, &c. &c.	Fossils.	Conditions indicated.
A. Volcanic Rocks.	*a.* Granitoid porphyry; trachyte and felstone.	......	Melted masses which have not flowed, or have flowed under water. Centres of volcanic action.
	b. Greenstone amygdaloid, basalt.	......	Melted masses which have flowed under water or in the air.
	c. Felspathic and augitic ash; agglomerate, &c.	......	Volcanic ejecta falling in shallow water.
	d. Black slate, sometimes amygdaloidal.	......	Mud derived from volcanic rocks, rearranged by shallow water, often heated by showers of hot ashes, vapours or currents of lava.
	e. Laterite, slate, baked clay.	......	Same origin and same conditions.
	f. Quartzite.	......	Geyserian action. End of the great volcanic eruptions approaches.
	g. Similar to *e.*	......	Occasional eruptions and slight fall of ashes and dust in shallow seas.

Formation	Masses, Beds, &c. &c.	Fossils.	Conditions indicated.
	ORGANISMS APPEAR.		
B. ZEEAWAN BED.	*a.* Crystalline limestone, coarse and with very few fossils.	Few.	Open sea coast, not very deep.
	b. Massive limestone, granular, or crystalline.	*Productus, Orthis, Spirifera, Fenestellidæ, Orthoceras.*	Open sea coast. About 50 fathoms.
	c. Ferruginous calcareous brown shales.	Same fossils.	Sea coast, not distant. Heavy water-fall on Volcanic islands.
	d. Dark sandy shales.	Same fossils.	Sea coast, not distant. Drift near shore. Heavy water-fall on Volcanic islands.
	e. Limestone, shaly, with shaly partings. Thickness = 200—250.	Same fossils; no *Bryozoa.*	Sea becoming shallow; shore shelving and drifty.
	FAUNA CHANGES.		
C. WEEAN BED.	*a.* Shaly and sandy limestone.	*Encrinites;* small bivalves; Debris.	Shallow shelving, coast line.
	b. Black argillaceous limestone.	Debris.	Shallow sea between islands.
	c. Altered, amygdaloidal limestone.	None or mere traces.	Local volcanic action; geyserian bursts of water or vapours. Earthquakes.
	d. Flesh-colored limestone with lenticular beds of pale blue, nearly friable limestone.	*Anthracosiæ. Aviculo-pectens. Pectens. Solenopsis.*	Proximity of land; banks and shallows on a shelving coast-line.
	e. Thin-bedded, argillaceous limestone, breaking in slabs.	*Goniatites.*	Slow formation of fine silt in well protected creeks.
	f. Shaly, muddy, very foetid limestone, with gregarious fossils.	*Cyrtia* and small *Terebratulæ.*	Warm, damp and shallow sea, swamps, teeming with life.
	g. Argillaceous and arenaceous limestone pale-less blue and yellow.	Debris of small thin bivalves. Roots of plants.	Very shallow sea-shore; sublittoral oscillations; frequent freshes of fresh water carrying mud to the sea.

Formation	Masses, Beds, &c. &c.	Fossils.	Condition indicated.
	FAUNA CHANGES.		
D. KOTHAIR BED.	a. Dark, blue or black argillaceous limestone.	*Gasteropoda* and *Cyathophyllidæ.*	Protected creeks, rather swampy.
	b. Slate and shale.	None.	Rivers bringing down mud to a shallow sea. Sublittoral oscillations.
	c. Sandy limestone without fossils.	......	Drift on shallow shelving coast.
	d. Shales; sandy shales; clay iron-ore in ribbons.	......	Shelving low land near sea-shore, traversed by rills from hot chalybeate springs. Sub-littoral oscillations.
	e. Limestone like a; passing into calcareous slates.	*Gasteropoda* and *Cyathophyllidæ.*	Shallow creeks or protected sea coast. Swamp with grasses? Shallows between tides?
	Thickness = 500 feet.		

This succession of beds shows a steady shallowing of the sea. If we reflect for a moment how the sea bottom which received the limestone was formed, by volcanic ash and ejecta falling into the sea around the craters of numerous volcanoes, we would be led to expect a shallow shelving sea coast. Whether the volcanoes had existed for ages and prevented the development of life during the Silurian epoch, or whether they broke out after the Silurian beds had been deposited and buried these beds under their ejecta, I cannot say. It appears much more probable however that the volcanoes existed during the Silurian epoch, and prevented marine animals from living, by keeping the water at such a temperature or permeating it by such gases as were incompatible with life. However this may be, there can be no doubt that the volcanic ejecta were disposed in very gently sloping beds all around the volcanoes which produced them, and, as these ejecta were arranged by water, we would naturally expect the beds they formed to extend far into the sea. Hence a long shelving shallow coast would be formed, a coast which would speedily become more and more shallow from the enormous

amount of sand and clay which was washed into it from the volcanic islands which studded it, by a rain-fall of tremendous volume.

57. We have yet to describe the second and third catenated chains of Kashmir; the second is marked by the summits of Liwapatur (13,012), Churn Wolkalbul (14,310), Girdwali (14,060), Batgool (14,423), Boorwaz (13,087), Handil (13,273), Saijhaha (11,334), and joins the first parallel at the Safapoor on the eastern shore of the Woolar lake. On the other side of the lake, it is continued by the Kahoota, the Manganwar (8,728), and the Sheri Bal. These mountains are all composed of volcanic rocks and of azoic slate interbedded with ash and agglomerate. They need not therefore be described in detail. The Boorwaz, Handil and Batgool form a porphyritic mass which is generally described by travellers as granite; it passes gradually on the west into amygdaloid and greenstone to form the summits of Saijhaha over the village of Gunderbul. The transition between the porphyry and the greenstone is a feldspathic rock of a pale colour and imbedding very numerous transparent crystals of quartz, a description of rock which is also found to form a passage between the porphyry and the felstone of the Kaj Nag. From the examination of a few specimens, kindly given to me by travellers, I have no doubt that the whole of this mass of mountains is composed of volcanic rocks, volcanic ejecta and slate. I am not aware that limestone exists anywhere amongst the spurs of these hills. Between the valley of Thral or Trahal and the river Lidar, there is a great labyrinth of mountains with many of the summits enumerated above, but I could obtain no information regarding them. I therefore requested Captain MacQueen, of the Punjab Irregular Force, who had arranged a shooting expedition to these hills to be kind enough to bring me a few specimens of the commonest rocks of the country he was about to visit, and also any rock which appeared to him in any way remarkable. By the use of the specimens thus obtained, and the examination of Captain MacQueen's route on the map, I was enabled to ascertain that the whole mass of these mountains is composed of the same volcanic rocks, which I have described in detail at the Tukt-i-Suliman and the Zebanwan. Ashes appear to have been accumulated in enormous quantity; they are interbedded with bands of black compact slate such as is so well seen

in the Wastarwan and Zebanwan, and both ash and slate are occasionally cellular or amygdaloidal. There is neither limestone, granite or porphyry among Captain MacQueen's specimens, and I believe therefore that the two last rocks at any rate do not occur in these mountains, as pieces of granite and porphyry generally attract the attention amongst the dull ash-rocks and would not have failed to form part of the collection, if they had existed. It is very possible that remains of beds of limestone are to be found amongst the spurs of the hills.

On the north of the Woolar Lake, many mountains of no great height form a sort of amphitheatre. They are nearly entirely composed of amygdaloidal greenstone, ash and slate interbedded, but near the village of Bundipoor, about two miles east of the road, some beds of limestone are seen. Mr. Drew has kindly sent me some specimens of it that are a flesh-coloured, sometimes greenish, very arenaceous and argillaceous. They are not at all crystalline, but contain an enormous number of encrinite stems transformed into spar with a cleavage oblique to the axis of the stem, so that when the section of a stem weathers, it appears striated across. This crystallisation has destroyed the structure of the stem, but the central canal is seen in a few specimens. We have seen this rock well developed at Manus Bal, towards the end of our section, where the beds of flesh-coloured limestone alternate with grey sandy limestone containing crinoid-stems transformed into a spar as black as coal. (See 35 of the section of Manus Bal). The limestone of Bundipoor is therefore Weean limestone.

On the west shore of the Woolar lake, the Taltiloo and the Chralkoot present perpendicular cliffs of volcanic rocks descending into the water. From a boat on the lake, it is easy to observe the usual thick and confusely bedded masses of greenstone and amygdaloid forming the centre of these hills, and the more sloping and regularly stratified layers of ash, laterite, agglomerate and slate well developed, in the long spurs which descend on all sides. The whole mass of hills appears to be made of volcanic rocks, and the lowest spurs which approach the shore of the lake present no fossiliferous beds. Of the higher peaks, the Kahoota, Manganwar and Sheri Bal, I know nothing, but there can hardly be a doubt, however, of their being volcanic in their formation.

58. The third catenated chain is composed of summits of great height, the Gwashbrari (17,839), the Harbagwan (16,055) the Basmai (15,652), and the Haramook (16,903), and many other peaks which, with their spurs and connecting ridges, separate Kashmir proper from Tillail and Gurais. All these high summits are formed by porphyry having a granitoid appearance, which passes, towards the north, into felstone generally earthy and similar to the earthy felstone of the Atala Mount near Baramoola. On the north-western extremity of the chain, this felstone becomes continued with that of the great chain of hills which unites the Kaj Nag to the Ser and Mer chain. This flaggy rock is continued to near the city of Gurais where, in the valley of the Kishengunga, beds of limestone appear extending from about 15 miles N. W. of Gurais to Tillail. The limestone is, after a break, continued at the Sono Murg and is in all probability identical to that of this locality. I have never seen any specimen or fossil from the Tillail limestone, but the Sono Murg limestone is Carboniferous, and it is most probable that the Tillail limestone, which appears to be the continuation of that bed, belongs to the same epoch.

Due north of Sono Murg, the limestone is much developed and forms the summit of a considerable peak.

The porphyry-centres of mountains pass towards the south to rocks of an appearance different from that of the northern spurs; while we have seen that, towards the north, the porphyry generally graduates to a felstone more or less earthy. Towards the south it changes, as we travel from the peaks towards the end of the spurs, into trachyte, greenstone, amygdaloid, basalt, ash and agglomerate, together with interstratified, azoic and often amygdaloidal slate.

The northern spurs of Gwashbrari, the Harbagwan and the Basmai are composed of felstone, and near the road to Drass, in the valley of the Sind Torrent, of amygdaloid and ash. On these beds of ejecta rest fossiliferous beds, and, near the small village of Sono Murg, the beds of limestone are well developed. Captain Godwin-Austen found in that locality some fossils which he was kind enough to show me. They were identical with the forms described as characteristic of the Kothair group of Carboniferous limestone, viz, the *Gasteropoda* and *Cyathophyllidæ* which are represented at Pl. VIII.

fig. 4, 4a. They occur in a thin-bedded, dark-grey, argillaceous limestone, having in some places the appearance of a calcareous slate. But beds of Wecan limestone must exist not far from Sono Murg and form propably some of the beds of limestone which are seen in the high valley between the Ambernath and the Gwashbrari, as blocks of limestone of this description, rounded by running water, were found in the bed of the Sind, near the traveller's home at Sono Murg.

To be continued.

EXPERIMENTAL INVESTIGATIONS *connected with the supply of* WATER *from the Hooghly to* CALCUTTA, *by* DAVID WALDIE, *Esq. F. C. S. &c.*

[Received 31st August, 1866.]

The attention which of late years has been given amongst civilized communities to the preservation of health and prevention of disease, has naturally been directed amongst other subjects to that of the water employed for economical purposes, and more particularly to its purity and wholesomeness as a beverage and as the medium for the preparation of food. The subject has been under the consideration of the municipal authorities of Calcutta, who, as is well known, have organised a scheme for the supply of the town from the river Hooghly, for the carrying out of which arrangements are now in progress. The Sanitary Commission appointed some time ago in the Bengal Presidency, and I believe in the other Presidencies also, recommended to the several governments of the Subdivisions, that the water of the various cantonments and stations should be subjected to chemical analysis for the purpose of ascertaining their wholesomeness, and these recommendations are in course of being carried out.

In England, and more particularly in the metropolis, much attention has been given to the same subject, and also to another one closely connected with it, namely, the disposal of the sewerage of towns. This subject is connected with that of water supply, not only, because in the plan generally followed for getting rid of sewerage in towns, a large

supply of water is necessary, but also on account of the circumstance that in many cases the readiest way to dispose of the liquid sewerage is to turn it into rivers. And as it frequently happens that these rivers may afford the easiest or perhaps the only practicable source of supply of water for other towns, the pollution of their waters so produced may be not a little deleterious. From the enormous extent and population of the English metropolis, and the comparatively small size of the river on which it stands, the evil in that case has become palpable and notorious. The most eminent chemists and engineers have been engaged in the examination of the subject as respects both the supply of water and disposal of sewerage, and the results of their enquiries have been published and subjected to public criticism and discussion.

So far as I am aware, nothing has yet been published of the results obtained by the examination of the waters of the Military cantonments of India, nor do I know if it be intended that anything shall be. With respect to the Calcutta supply, as is well known, a series of analyses has been made, and a Report of results and conclusions drawn out, by the Chemical Examiner to Government, Dr. Macnamara. That report, no doubt from being intended for a non-professional, and (regarding it collectively and officially) not a professedly scientific body, gives only results and conclusions, omitting altogether the details of analyses and the specification of the methods employed. Dr. Macnamara's attention seems to have been directed chiefly to the water of the Hooghly, to ascertain the proper point nearest to the town from which a supply of water of sufficient purity all the year round could be obtained. The examinations were made on samples from Cossipore, Pultah Ghat near Barrackpore, and Chinsurah. The general conclusion arrived at is, that the influence of the tide is little felt at Chinsurah at any period of the year, not much more at Pultah Ghat, except towards the close of the hot season in May and June when it is decidedly perceptible though not great, and not only decided but to a large amount at Cossipore during the months of March, April, May and June; and that the river water from its admixture with sea water and the sewerage of Calcutta during that time is unfit for human consumption. The organic matter is stated to be much larger in quantity during these months than at other periods, and also to be highly nitrogenized; the quantity amounting to 6 or 7 grains or even 10 or

12 grains per Imp. gallon during the months of April, May and June; and this increase in quantity and deterioration in quality is considered to be due to the organic impurity from the sewers and banks at Calcutta. The analyses, I may observe, were chiefly made on samples taken at high water, obviously to get the water at its worst. Analyses are also given of the waters of two tanks in the Maidanu or plain round Fort William, namely Monohur Doss's Tank and General's Tank, which are considered as unquestionably superior to the river water.

I may observe that, when I commenced this investigation, it was not in connection with the water supply of Calcutta at all, or even in connection with the economical use of water or its wholesomeness as a beverage. These enquiries had been placed in the hands of others; but it occurred to me, that residing, as I did, on the banks of the Hooghly, and possessing certain facilities for the purpose, it might be a contribution to science of some small value to make a minute examination of the constituents of both the water and the mud of a great river draining so large an extent of country as the Ganges. The investigation is as yet far from completion, but during its course, it occurred to me that many of the results obtained might have some value in relation to the subject just adverted to—the economical use of water; and that the local interest attached to it might render it in some degree appropriate to publish these results, more particularly at a time when all the knowledge attainable connected with the subject is desirable.

This communication then is not intended to present a full statement of the composition of the Hooghly water, but only to treat of such points as are of more particular interest in connection with its application to supply the wants of the inhabitants of Calcutta. And indeed this is all that is necessary for the purpose in view. As regards the general composition of the river water at different seasons of the year, my own results only go to confirm those already given in Dr. Macnamara's Report, but in some particulars, not of minor importance, the results I have obtained and the conclusions drawn from them are somewhat different; and in other particulars it may be found that I have added to the stock of information on the subject.

It is scarcely necessary to allude to the course of the seasons in Bengal and the way in which they affect the river. But for

convenience I shall briefly state how I shall speak of them in what follows. From the middle of June when the rains generally commence and the river rises, till the end of October or middle of November, when the rains have ceased and the river is rapidly falling, I shall speak of as the rainy season; thence till the end of February as the cold season; and thence again till the rains recommence as the hot season. The first is identical with Dr. Macnamara's "Full season," the two latter with his "Low season."

During the rains, the river comes down in full stream from the parent Ganges through the effluents which unite to form the Hooghly, viz. the Bhagiruthy, Matabangah and Jellinghy, with contributions from other tributaries from the west. During that period, and more particularly during its earlier part, the water is loaded with mud in a very fine state of division and very slow in settling. As the season comes near its termination, the water becomes clearer, and remains so during the cold season, any mud in suspension rapidly settling. The water, which during the rains naturally contained the smallest proportion of saline matter, now contains more, the proportion gradually increasing till the end of February, the first increase having been more rapid at the stoppage of the rains. All this, of course, is the natural and obvious result of evaporation without any rainfall to supply the place of the lost water, aggravated by the diminished supply of water from the Ganges caused by the bars at the entrance to the tributary effluents. These causes operate with still greater power during the hot season, aided by strong southerly winds and powerful tides. During this season the mud is stirred up, and the water rendered more dirty, but the mud is not in the same state as during the rains, and settles without difficulty. The influence of the tides becomes increasingly felt as the season advances, and the admixture of sea water becomes unmistakable.

The following table exhibits the results I have obtained as respects the amount of solid residue obtained by evaporating the water. They are given for 100,000 grs. of water, instead of the Imperial gallon used by Dr. Macnamara. By multiplying by 7 and dividing by 10, the quantities per gallon are obtained.

The following Table showing the amount of solid matter dried at 212° to 220° Fah. in the river water at ebb tide, at a point from two to three miles above Calcutta.

TABLE I.

		For 100,000 grs.	For 70,000 grs, or Imp. gall,
1865			
August 31st, 1865, including very fine clay,*	Ebb,	12.13	8.41
December 6th,	Ebb,	24.00	16.80
1866			
February 25th,	Ebb,	30.00	21.00
May 2nd, spring tide,	Ebb,	36.20	25.34
	Flood,	88.50	61.95
24th, Neap tide,	Ebb,	21.25	14.88
June 14th, spring tide,	Ebb,	30.70	21.49
	Flood,	151.90	106.33
July 6th, including very fine clay,*	Ebb,	12.59	8.81
August 8th, clay and some silica deducted,	Ebb,	8.13	5.69

These numbers confirm the results exhibited by Dr. Macnamara's report, making allowance for difference of seasons. They shew clearly the increase of solid contents more especially during the dry season. And here I may remark that samples were chiefly taken during ebb tide, as my primary object was the examination of the river water proper, and it was only during the hot season that particular attention was paid to the state of tide, after my attention had been directed in part to what is the special object of this paper. And indeed, except during the hot season, the composition of the water is little affected by the tides.

And further, as the object was to make a full analysis of the water at several different seasons, I did not adopt the readiest or simplest methods of merely comparing the water at different periods for sanitary purposes, which would have been done, had that been my primary object. The methods adopted will be noticed in due course.

The preceding table exhibits a very great variation in the amount of solid constituents during the hot season, owing to the influence of the tides, a subject which will be separately considered.

* These waters had settled well—that of August 1865 for 19 days, that of July 1866 for about 35 days, yet by comparison with that of August 1866 it will be observed that about one third of their solid contents was fine clay.

Influence of the Tides.

It will indeed be convenient to take up this subject first in order. Dr. Macnamara's results exhibit very clearly the increased quantity of saline constituents during the hot season, commencing in March, and coming to its height just before the commencement of the rains. His table shews as much as 77.7 grs. dry saline residue from 1 gallon of water at high water on 12th June, 1862. I obtained from water taken at full spring tide, on 14th June of this year 1866, as much as 106.3 grs. per Imp. gallon. This is easily accounted for when it is found, as ascertained from examination of the rainfall, that from June 1861 to end of May 1862 there had fallen 87.4 inches of rain, while during the corresponding period of 1865-66 there had been only 47.9 inches: the river must have been much lower and its current feebler, and consequently the sea water had penetrated farther. My observations were all made on water taken from the river near my own residence at the village of Baranagur or Barnagore, with a few exceptions which I shall notice afterwards. The locality is about two miles above Cossipore. But I made observations also on the effect of time of tide.

This point is also noticed in Dr. Macnamara's report, though not very fully. He mentions that the water varies much in the degree of its impurity with the time of tide, falling as low during April and May as 23° at low water, that is, 23 grains of saline matter in 1 gallon. My observations indicate even a greater amount of variation than is by this suggested, as will be shown by the table I have prepared. As the evaporation to dryness and weighing the residue of numerous samples is very tedious and troublesome, another plan was adopted for estimating the amount of variation. The river water proper contains very little chlorine in its composition, while in the state of common salt this is the characteristic constituent of sea water. The quantity of chlorine was therefore ascertained by the usual volumetric process with nitrate of silver, and calculated as if it existed entirely as chloride of sodium or common salt, which afforded a very good means of comparing the samples and estimating the proportion of sea water present.

I endeavoured to make some observations further up the river, but found that it could not be done properly except with an expenditure of time, trouble, &c. that I could not devote to it. Any observations that I did make were only confirmatory of Dr. Macnamara's results.

The following table exhibits the results of my observations on the

influence of the tides. The change of course is gradual, commencing in March and increasing as shewn by Dr. Macnamara's report. I did not make observations until the first of May.

TABLE II.

To compare Ebb and Flood Tide. 1866 a mile above Baranagar—		Chlorine calc. as Chloride of Sodium. For 100,000 grs.	Saline matter dried at 220° F. For 100,000 grs.	Saline matter dried at 220° F. Imp. gal.
May 1st, second day of full moon.				
Low water nearly complete, ...			28.0	19.60
High water nearly complete,	Surface,		61.55	43.08
	Deep,		59.55	41.68
At Calcutta—				
2nd, third day of full moon,				
About $\frac{7}{8}$ Ebb, stream, Opposite Bankshall.	Surface,		36.20	25.30
	Deep,	15.50		
About $\frac{3}{4}$ Flood, stream, Opposite Hatkolah.	Surface,		88.50	62.19
	Deep,	55.50		
At Baranagar—				
16th, third day of new moon,				
Above 1 or $1\frac{1}{2}$ hour Ebb,	Surface,	40.00	66.40	46.48
	Deep,		68.60	
Above $\frac{3}{4}$ Flood,	Surface,	78.00	107.20	
	Deep,	75.00	109.00	76.30
Nearly high water complete,	Surface,	82.50	104.70	
	Deep,	80.00	106.20	
To shew state at Neap tide.				
24th, fourth day of first quarter of moon.				
1 hour after beginning of Ebb,	Surface,	17.50		
	Deep,	18.50		
3 hours after do.	Surface,	12.50	21.25	15.05
	Deep,	11.50		
To shew rate of change during Ebb and Flow.				
May 30th, third day of full moon.				
At shore 5 h. before tide begun, ...		27.00		
2 h. before do, ...		21.50		

Stream, above 4 hours flood,.........		64.00	83.85	58.7
June 1st, fifth day of full moon.				
5 h. 10 m. before tide begun, ...		35.00		
1-20 ditto ditto, ...		16.50		
2-10 after ditto, ...		26.50		
5-10 after ditto,	Surface,	69.50		
	Deep,	58.50		
14th, third day of new moon.*				
Tide commencing about noon,				
At 6 h. 40 m. A. M.	Surface,	63.50		
	Deep,	65.90		
11-5 A. M.	Surface,	15.00	30.7	21.49
	Deep,	14.00		
2-20 P. M.	Surface,	71.00		
	Deep,	85.50		
4-20 P. M.	Surface,	123.00	151.9	106.33
	Deep,	126.00		

The water was collected either by filling vessels from the surface, or in the case of the deep water by lowering a tin bucket provided with proper valves. The much larger quantity of heavier mud brought up by the bucket proved that it acted properly. The water was collected in almost every instance under my own personal superintendence.

The collection was made by means of an ordinary small boat or dinghy. The changes of position which could not be avoided account for the irregularities between the surface and deep waters, taking into account the strong currents and eddies that prevail.

The table exhibits the great influence of the tides: taking the extreme case of 14th June after long drought, just two days before the rains commenced, we have in 100,000 fl. grains of water 151.9 grs. solid matter at high water, and 30.7 gr. at low water, or nearly 5 to 1; while comparing the Chlorine as Chloride of Sodium or common salt, the proportion is fully 8 to 1. These great differences occur chiefly at spring tides. The results of 24th May shew how comparatively small this is at Neap tides, 19 grains of salt at nearly high water to 12 grs. at nearly low water.

* Highest tides are on third day of new or full moon.

A study of the particulars of this table shews that the period during which the water can be obtained with the smallest admixture of sea water is during the last three or four hours of ebb tide and the first one or two of flood. From tables of the analyses of the waters supplied to London which I shall have to refer to more particularly afterwards, it appears that the water of five Thames Companies contains at an average from 26.41 to 26.97 grs. of saline matter per 100,000*; and that of four other Companies,—two river waters contain about 26 grs., and two artesian well waters contain from above 38 to 40 grains. The Hooghly water at Baranagur therefore even during the hot season at ebb tide contains little more solid matter than the Thames water, but probably a larger proportion of this is salt.

Constituents of River Water proper.

We have now to direct our attention to the river water proper, which we may consider that we can get from the Hooghly at different degrees of dilution all the year except three or four months of the hot season. The water of rivers is of course in greater part generally water fallen from the atmosphere. Aided by the carbonic acid of the atmosphere, it acts upon rocks, even silicious rocks, producing a certain amount of decomposition and carrying off their constituents partly in solution, partly in suspension as mud; it carries off similar constituents from the soil, which consists of decomposed rocks; and also from this source a quantity of organic matter, the result of the decomposition of vegetable and animal substances, as also the excrementitious matters deposited there. Except in special circumstances the water of rivers generally contains a rather small proportion of alkaline salts in the state of silicates, sulphates, chlorides and carbonates, with a larger proportion of carbonates of lime and magnesia kept in solution by excess of carbonic acid gas. They differ from spring or deep well waters and agree with surface waters generally in containing a notable proportion of potash as well as soda, and also more silica, phosphates, earthy carbonates and organic matter, and sometimes ammonia and nitrates, than deep spring waters do. When brought in contact with argillaceous deposits, they part with their potash, ammonia, silica, phosphoric acid and organic matter, while the soda, lime, magnesia, sulphuric acid and chlorine are generally retained, forming the usual constituents of spring waters. This subject is treated of fully in an Essay on the

Chemistry of natural waters by Mr. T. Sterry Hunt, which will be found* well worthy of perusal.

I am not aware whether much consideration has been given to the peculiarities of the constitution of such surface waters in regard to their mineral constituents and their action on the animal economy, except in the case of the abundance of earthy carbonates. This, however, is perhaps the least characteristic of these constituents, as many spring waters abound in earthy carbonates, or at least in earthy salts, sulphates and muriates of lime and magnesia. More characteristic is the deficiency of muriate of soda or chloride of sodium in the surface waters and its comparative abundance in spring waters. Soda is the characteristic alkali of the components of the human body, but some curious observations have been made by physiological chemists on the relative proportions of the two alkalies in different parts or tissues of the system; and though it is stated in these cases that the peculiarities exist entirely irrespective of the nature of the food taken, it would scarcely be warrantable to assume as certain that such differences in the predominance of potash or soda in food or drink are entirely destitute of influence. The point is at least worth bearing in mind.

Phosphoric acid, when present, exists in such small quantity that only in very minute analyses is it sought for by the analyst. Silica is found much more generally. From its neutral and indifferent character, much attention has not been given to it in its influence on animal bodies. But attention has been given to all of these substances in relation to vegetable physiology, as plants draw their food directly from the soil in part at least, and the nature of its constituents is therefore of immediate importance.

To the other constituents I have mentioned, namely organic matter with the products of its decomposition, including ammonia and nitric acid, more attention has lately been paid in connection with water to be used for human consumption. Indeed this may be said to be the principal point to which the analysis of waters selected on sanitary considerations has of late been chiefly directed.

The water of the Hooghly has a composition similar to that already given as that of river waters generally. According to Dr.

* *Silliman's American Journal of Science for March, July and Sept. 1865.*

Macnamara's report, in the month of August there was in 1 gallon of water 1.2 grains of soluble salts and 5.4 grs. of insoluble earthy salts, beside silica and organic matter, and in February 1.8 of soluble and 13.4 of earthy. Or, as I prefer to express it, there was in August 1.7 grs. alkaline salt and 7.8 grs. earthy carbonates in 100,000 fl. grs., and in February 2.6 alkaline salt and 19.1 grs. earthy carbonates in the same volume. The first represents the water in its most diluted state during the height of the rains, the last in its most concentrated state at the end of the cold season, just before tidal influence begins to be felt. I do not intend to give any of my own results, partly because a full analysis of the water is not the object of this paper, and partly because a circumstance entirely unforeseen and unexpected has thrown doubts on the correctness of some of those obtained, and I do not wish to give them in an imperfect state, as they cannot be corrected until the return of the cold season gives me a new supply of water. It is sufficient to say that they do not appear to differ materially from those given in Dr. Macnamara's report. The only point to be noticed is, that Dr. Macnamara, in accordance with the usual custom, where minute accuracy is not required, assumes that the alkali is soda. Both potash and soda, however, are present in the river water; to what extent they vary, I have not yet ascertained. During the hot season, from the increase of common salt from tidal water, there is of necessity a great increase in the proportion of soda in the state of common salt.

The alkaline salts consist of potash and soda in combination with sulphuric acid, silicic, and probably hydrochloric acid (or more strictly their metals combined with chlorine) and perhaps some organic acid. The earthy salts are carbonates of lime and magnesia, kept in solution by excess of carbonic acid. On evaporation nearly the whole of the lime and magnesia separate as carbonates insoluble. Besides these there are a few minute constituents to be noticed afterwards. The only particular now to be noticed is, the different proportion of solid constituents in the water at the two extremes; in August there is 9.5 grains of alkaline and earthy salts in solution in 100,000 fl. grs. of water, in February there is 21.78 grs. or about two and a quarter times as much. This great difference is of course due to the nature of the seasons in Bengal, where almost all the rain falls during four or five continuous months.

It may be useful to refer for the purpose of comparison to the composition of some other waters supplied to towns, and I shall take for that purpose one of the most recently published reports on the subject, namely, that by Professor Frankland on the water supply of London during the year from February 1865 to January 1866.* The only points determined connected with the mineral constituents are the total amount of saline matters and the amount of earthy salts as ascertained by the soap test; this, as is well known, being the application of the familiar fact that hard water curdles soap, to ascertain its purity; a solution of known strength of soap being added to a measured quantity of the water to be examined from a graduated tube, until the curdling effect of the salts of lime and magnesia which cause the hardness is exhausted, and the water produces a lather on shaking. The quantity of soap required indicates the amount of earthy salts present; an easy and speedy means of obtaining a sufficiently good estimate of the amount of earthy salts in water.

By deducting from the total solid matter first the amount of organic matter, the total inorganic is obtained; and by deducting from this the amount of carbonate of lime, the remainder will indicate, with sufficient approximative accuracy, the amount of alkaline salts. Here are the results of this proceeding—for the waters of

	Five Thames Companies average.	New River and River Lea.	Kent and S. Essex Co.'s Artes. Wells.
Total solid matters, mean	26.63	26.11	39.03
Deduct organic and volatile, mean	1.60	1.30	1.73
	25.03	24.81	37.30
Carbonate of Lime	17.69	20.65	25.16
Alkaline salts	7.34	4.16	12.14

It will be observed that the alkaline salts are in much larger proportion to the earthy carbonates than in the Hoogly water, this being specially the case in the Artesian well waters. The waters of New River and River Lea come nearest the Hooghly. The amount of solid matter is much greater in the average than that of the Hooghly river

* Journal of the Chemical Society, June 1866.

water proper, the mean indeed being nearly as much as the maximum of the Hooghly before tidal influence begins. The amount of variation is much smaller in these waters: of the Thames water the highest quantity of solid matter was 32.62 grs. the lowest 18.78, and the well waters vary less. And it was observed that the quantity of solid matter tended to increase after heavy rain fall.

Other river waters contain more or less of such constituents, dependent on the nature of the rocks and soil they traverse. Mr. Sterry Hunt gives an analysis of the Ottawa water, taken before the melting of the snows, containing 6.12 grs. solid in 100,000. Bischoff, in his Chemical Geology, gives a pretty large list of analyses of river waters, showing a variation of from 2.61 to 54.5 grains solid matter in 100,000. The nature of their mineral constituents also varies greatly, but that will not engage our attention at present as it is more a geological question than a sanitary one. We shall proceed to the point more immediately connected with the object of the paper.

The substances treated of can scarcely be called impurities with reference to natural waters. They are rather constituents, and are only to be considered impurities in a sanitary point of view when they are excessive in quantity, as for instance exceeding 40 or even 50 grains in 100,000. The remaining substances to be noticed may in a purely chemical point of view be called constituents also with quite as much truth, but with reference to sanitary considerations may with propriety be termed impurities. They were enumerated before as organic matter, ammonia and nitric acid. It may be better to consider them as organic matter of vegetable origin and organic matter of animal origin, with the respective products of their decomposition.

Vegetable substances of all kinds mixed with the soil, exposed to air and moisture or immersed in water, dead animal bodies of every variety in similar circumstances, all rotting, fermenting and putrefying, with the excrementitious matters from living animals, constitute the materials from which river water derives that portion of its constituents called organic matter. Its nature is so heterogeneous and its quantity so small, that it would be hopeless to attempt to separate it into its proximate constituents. All we can attempt is to get some general idea of its nature, from which to form some judgment of its

properties, especially with reference to its action on the human system. Of late more attention has been paid to this subject, previously little thought of.

The first point requiring attention is to ascertain its quantity as correctly as practicable. The plan formerly followed was to dry the solid contents of the water obtained by evaporation carefully at a certain fixed temperature such as 212° or 250° F., or even about 300°, till the weight remained constant; then to burn off the organic matter by as moderate a heat as possible and weigh again: the loss of weight was considered organic matter. But this method is liable to great error, and may give grossly erroneous results. Other substances may be volatilised: salts of ammonia have been mentioned, but they may be included amongst organic matter; nitrates may be partially or wholly decomposed, but they generally exist in very small quantity. Earthy carbonates may lose carbonic acid:—carbonate of lime will not readily lose it if the heat be moderate, but carbonate of magnesia will very readily, and moreover chloride of magnesium (or muriate of magnesia) loses part of its acid easily. It is the magnesium salts which are the chief source of loss, but this can be prevented or remedied. If the contents of the water be not naturally sufficiently alkaline, a sufficient quantity of accurately weighed and perfectly dry carbonate of soda is added to the water on evaporating it; the soda combines with hydrochloric acid to form chloride of sodium and water, while the magnesia remains as carbonate; and by this means, as the chlorine is not separated by ignition from the sodium, the loss of chlorine is avoided. The only loss is of carbonic acid, which can be restored again. This is done by adding to the ignited residue in the platinum crucible distilled water charged with carbonic acid and evaporating to dryness by gentle heat, drying again at the same temperature as was employed at the first weighing before ignition till the weight is again constant. The loss of carbonic acid is by this means corrected, the acid being restored, and the difference of weight shows the quantity of organic matter, at least more correctly than by any other method known.

This plan is attributed to Dr. Thomas Clark, the inventor of the soap test, by Dr. W. Allen Miller in a paper* to which I shall have further occasion to refer. It is tedious and troublesome, requires a fine balance,

* Journal of the Chemical Society for May, 1865.

patience, and care; but it is not too much to say that the results obtained without the above detailed precautions are of no value, or rather worse than useless, as they mislead. The results which I shall give were obtained by this plan carefully carried out. It will be found that they differ materially from those given in Dr. Macnamara's report; and I can only account for the discrepancy, by supposing that some precaution requisite for ensuring accuracy in the process was omitted, either from inadvertance, or because it had not at that time (1862) been generally known to or used by chemists.

In the table in that report the smallest quantity of organic matter entered is 0.9 grain in 1 Imperial gallon, the largest 8.3 grains, generally however 3 or 4 grains per gallon, which are equal to respectively 1.23, 11.8 and 4.3 or 5.7 grains per 100,000 grains. My own results have yielded me only from 0.6 to 1.9 grains in 100,000 and Dr. Frankland's in the report already alluded to, vary from .54 to 3.3, or average about 1.6 for the Thames, and 1.3 for the other two river waters. The table which will be given will exhibit the results I have obtained, Remarks will be postponed till the whole subject is considered.

The time, trouble, and care necessary for estimating the amount of organic matter by weight is so great, that chemists have been desirous of finding some easier and speedier method of estimating its amount. Precipitation of the organic matter by salts of lead or reduction of salts of silver and gold have been proposed, but never come into general use. But another re-agent has of late been very generally employed, the permanganate of potash, which from the facility with which it yields its oxygen to organic substances has been made the means of estimating the amount of these; and as it can be very easily employed, it has come very much into favour. A good deal of difference of opinion prevailed at first as to the proper method of applying it and as to the value of its indications, but more agreement is being arrived at lately. It is used in the state of weak solution poured from a graduated tube, and the permanence of a slight pink tinge in the water to which it is added is the sign of the action being complete: the quantity by measure of the solution required indicates what is wanted. Dr. Letheby continues to add the solution at intervals for 24 hours: if the action was completed, then this would be very well, but it is not, as there are different kinds of organic water, some

of which act slowly on it, others more rapidly. Dr. Miller strictly enjoins that the water should not be warmed, without however stating any reason, and other English chemists seem also to practise it cold; Dr. Woods, who wrote a paper on it some years ago published in the Chemical Society's Journal, recommends warming the water, as also does Dr. Macnamara, and gives reasons for it. It now generally seems to be agreed that it is desirable to restrict the use of the permanganate to the oxidation of those substances that can be rapidly acted on; and after consideration and experiment, I have adopted with some small modifications the details of Dr. Frankland's practice, except that the water is heated to about 120° F. at the commencement. English chemists forget that what is our natural cold here, requires artificial heat with them, and that it is desirable to follow a plan that can be easily made uniform for all climates. The solution of permanganate is added in small portions at intervals, until a perceptible tinge of pink remains for ten minutes; when this is the case, the quantity used is read off. I use 4000 fluid grs. of water with 80 fluid grs. of diluted sulphuric acid, containing 1 grain concentrated acid by weight in 5 fl. grs., heat the whole to about 120° F. and having removed it from the lamp, proceed to add the solution. This is made of such strength that each measure of the tube (it may be, each equal to 1 cubic centimetre or to 10 fluid grains) yields .001 grain oxygen as ascertained by its action on oxalic acid in solution in similar circumstances, that is dissolved in a similar quantity of pure distilled water with the same quantity of sulphuric acid and treated in the same way. As .63 grains oxalic acid requires .08 grain oxygen, the solution will be of proper strength, if 80 measures are required for oxidizing that quantity of oxalic acid: that is, 80 measures are equal to .08 grain oxygen, or 1 measure is equal to .001 grain oxygen.

Although it is certain that in many or most cases the permanganate as used in this process does not oxidise all the organic matters, and that we cannot tell how much remains unacted upon; and though at present at least we do not know what is the particular chemical constitution of the matters oxidized, it is at least certain that it acts upon those substances which give the putrid odour to stagnant water, and renders them after a time, when the products of its action have settled, pure and transparent and quite free from offensive smell.

It thus removes the matters which are actually in a state of putrefaction, and I believe preserves the water from further putrefaction for at least a considerable time. For this purpose it is advantageously employed for the purpose of purifying water for domestic use. In such application it is used alone, no sulphuric acid being used: a very small quantity being added to the water, just sufficient to give it a very slight pink tinge, which will remain for above 15 minutes; the water is allowed to stand till next day, and is then decanted off and filtered and is fit for use. The minute quantity of potash salt produced can do no harm.

Provided it be properly understood what the use of this re-agent indicates, and it be not credited with more than it does effect, the permanganate test is a valuable addition to our means of examining the quality of drinking water. The results of my examination of the Hooghly water by means of it, and the amount of organic matter by weight, are given together in one table.

The quantity of oxygen required is very small. The results are given as obtained, but cannot be counted on too minutely, as there is a certain amount of error unavoidable, in not getting the colour exactly of one degree of intensity, in slight difference of quantity required dependent on rapidity of adding the liquid, and probably on other causes not very well ascertained. The purity of the waters as respects such offensive constituents is in proportion to the oxygen required to oxidize them: the purer the water the less oxygen is necessary.

Table III.

River water taken from the Hooghly two to three miles above the north end of the town, except when otherwise specified.

For 100,000 fl. gs. water.

	Organic matter dried at 212° to 220° Fah. Grains.	Oxygen required. Grains.
6th July, 1866 Ebb, from surface, ...	.80	.0375
10th ditto, from shore, ...		.0338
8th August, Ebb tide, ...	.60	.0450
21st ditto ditto, ...	.86	.0345
31st August, 1865, Ebb tide; had stood in stoppered bottles ten months, and much vegetable growth had been removed, ...	.74	.0225

9th December, 1865, Ebb, Surface,	... ...	1.02	
Deep,	... ...	.78	.0175
25th February, 1866 Ebb, Surface,	... ...	.92	
Deep,	... ...	.45	
2nd May, Ebb at Bankshall, southern part of Calcutta,	... ...		.0325
Flood at Hatkolah, northern part of Calcutta,	...	2.70	
30th May, Ebb,	... ...	.90	.0238
Flood,	... ...	2.60	.0275
14th June, Ebb,	... ...	.90	.0250
Flood,	... .	2.20	.0225
6th June at Chandernagore, 20 miles above Calcutta, Ebb, Surface,	... ...	.60	.0163
Deep,	... ...	.67	.0213

From an inspection of this table, it will be observed that the permanganate test exhibits the largest quantity of organic matter in the river water during the rainy season, and the smallest quantity during the cold season, the hot season giving results intermediate.* The same ratio is not so distinctly perceptible in the weight of the organic matter. If the water at all these seasons were at the same state of dilution as regards saline matter, there would be the largest proportion of organic matter during the rainy season and the smallest during the hot season. The hot season is usually associated with ideas of corruption and concentration of impurities, the rainy season with purification by the abundance of pure water from the clouds. In point of fact it is directly the reverse. The same thing has been observed in England, as will be manifest from the following quotation from Dr. Frankland's report on the London waters. He says, "This

* It was with considerable hesitation that I left the indications given by the permanganate test in the table, on account of objections raised to my determinations of the organic matter which led to a supplementary paper read at the succeeding meeting of the Society. But after due consideration, they were allowed to remain as sufficient for the purpose required. The objections will be noticed as occasion calls for it, in notes or in the Supplement.

It is to be observed also that, as reported in the Proceedings of the Society for October, page 1866, I had stated 1.4 grains per gallon as the largest amount of organic matter obtained. Two of the results in the table, those of 2nd and 30th May somewhat exceed this, viz. 2.7 and 2.6 grains corresponding respectively to 1.89 and 1.82 grain per gallon. The correctness of these was doubted from supposed inaccuracy in the process, but this not being certain they have been introduced into the table. 30th Nov. 1866.

comparison shews clearly (as might be anticipated) how closely the condition of river waters is connected with the amount of rain-fall; but, in opposition to the commonly received opinion, it proves that the waters in question are much purer in dry than in wet weather, even if the drought occurs during a very hot summer." He seems, however, to hesitate a little about drawing general conclusions from the observations of one year; and in the report of the discussion which followed at the Chemical Society's meeting as reported in the Chemical News, some of the speakers seemed inclined to attribute it to special and particular causes. I have no doubt that it is owing to general causes, and that when we consider the circumstances, we cannot expect any other result.

Unfortunately in the case of the Hooghly at Calcutta, the question is complicated by the admixture of sea water during the hot season. This introduces two sources of error into the process of examination, namely an increased amount of saline matter, and a difference in its nature and properties. These will probably tend to cause indications of an amount of organic matter in excess of the truth. The point is under examination. There is also great difficulty in estimating correctly the amount of organic matter during the rainy season, on account of the impossibility of getting the water clear by filtration, and the very long time it requires to become clear by subsidence. This point is also under investigation.*

There can be no doubt also that the kind of organic matter in the sea water mixture is different in some respects from that of the river water proper. I was much struck with the observation made many months ago of the difference of colour presented by the different specimens of water when highly concentrated, that of the August water being so much deeper in colour than the others. On the contrary, a sample of water from the salt water lake to the east of Calcutta, though indicating both by the weighing and the permanganate processes much more organic matter than the river water, when concentrated, was almost colourless.

But to return to the greater proportion of organic matter during the rains, it seems to be nothing but what may be expected. During the

* For the reasons stated there is considerable uncertainty respecting the correctness of the weight of organic matter in the waters of July and August

remainder of the year, vegetable and animal matter of every kind is deposited in or upon the soil in all stages of decomposition. The amount of drainage is small and the flow of water gentle: the water carried thus to the river is comparatively pure, and that from the sources of the streams is from places bare of vegetation and part of it from melting snow. But when the rains come, they wash off all the accumulated products of decomposition of vegetable and animal substances in the state both of solution and suspension, of which the appearance alone of the water and its flavour give ample evidence. The increased proportion, it is true, is counteracted by the largely increased quantity of the water which dilutes it; for if, instead of looking to the proportion of organic matter to the water, we look to its amount in proportion to the inorganic or mineral saline matter, then in the rainy season the excessive proportion of organic matter is rendered much more evident. After the rains the mud subsides, which is favourable to the purification of the water, and the atmospheric oxygen contained in solution in the water, as it is in natural waters generally, acts upon the organic matter in solution, oxidizing and destroying it. And as heat in general materially increases the energy of chemical action, there can be little doubt that this purifying influence goes on more rapidly in tropical than in temperate climates, and that this explains why the organic matter in the Hooghly water is smaller in amount than that of the London waters, both of river and wells in their natural state.

But we have to consider not only the quantity but the quality of the organic impurity. We can scarcely expect to go more minutely into this than to endeavour to ascertain the relative proportions of vegetable and animal matter, and to get some idea of their state or of the stage of decomposition in which they exist in the water. The chemical constitution of these gives us some aid in this enquiry, the main constituents of vegetable compounds being carbon, hydrogen and oxygen, those of animal substances containing nitrogen in addition; a statement which, though not strictly exact, is sufficiently characteristic, so much so, that by azotized or nitrogenous substances are generally understood compounds of animal origin. The ultimate products of the decomposition of non-nitrogenous organic matter in presence of oxygen, namely water and carbonic acid, of course give us no help in this enquiry, nor are the intermediate products likely to be

possessed of any such striking properties as to aid us much, as they are mostly of a neutral nature without active chemical or physical characteristics. Nitrogenous bodies, however, yield products more readily recognised, and as it is this class of substances which are most likely to possess properties injuriously affecting the animal economy, their detection is also the most important.

The ultimate products of the decomposition of nitrogenous organic substances are, in addition to water and carbonic acid, also ammonia, and where excess of oxygen is present, nitric acid. But there are also numerous intermediate products, and these are often characterised by offensive smells which give a certain character to the putrefaction of animal substances, different from that yielded by the fermentation or corruption of vegetable bodies. The smell or flavour then of a water is a very good test of its purity, though it indicates rather the stage of decomposition in which its organic matter exists than the amount of organic matter present. And in connection with this I may mention the test of keeping the water and observing the changes which take place in it, the production of animalcules or of aquatic vegetation. Now I have kept samples of water taken from the river at all seasons for many months. Those taken during the cold and hot seasons settled easily and suffered very little further change; at the most a little greenish deposit at the bottom of the bottle formed, which is the case, however, with ordinary distilled water. It was very different, however, with the water of the rainy season. Some water taken from the river on 31st August, 1865, was kept for about two or three weeks, then syphoned off the deposited mud into other clean stoppered bottles in which it remained, the bottles being closed for about four months, when the bottles were found to have their sides covered with abundant green branching vegetation: the water was again syphoned off quite clear to other clean bottles and kept for about six months longer, when the same appearances were observed, though to a much smaller extent. There was abundant proof in this case of the presence of organic matter, probably both in the form of living germs and of chemical compounds dissolved in the water. The water taken during the hot season may have contained as much: possibly the presence of the excess of saline matter may prevent such development, but I am not prepared to give an opinion on the subject. The

water of the hot season shewed more indications of vegetation than that of the cold season, though greatly less than that of the rains.

Ammonia.

Ammonia, perhaps one of the most characteristic evidences of the presence of nitrogenous matter, can be detected in natural waters, and even when in such minute proportion as in natural waters, its quantity can be estimated. Dr. Miller has given a process for doing so with sufficient accuracy, and without the necessity of operating on very large quantities of water, which will be found in the paper I have already mentioned on the analysis of mineral waters in the Journal of the Chemical Society for May 1865. It depends on the great delicacy of the test for ammonia possessed by an alkaline solution of the Hydrarg-Iodide of Potassium, which produces a fine rich yellow brown colour with a very small quantity of ammonia, or a precipitate, if the quantity be larger. In the weaker solutions, the colour varies in depth of shade with the proportion of ammonia present, and by a comparison with another solution containing a known quantity of ammonia the proportion is estimated. Dr. Miller attributes the plan of proceeding to Mr. Hadow, and gives the details of procedure. He gives the formula for the preparation of the alkaline solution of Hydrarg-Iodide of Potassium, which I have strictly followed and adopted. His standard solution for comparison is a weak solution of pure muriate of ammonia of such strength that 1 fluid grain of the solution contains .0001 (one ten-thousandth of a) grain of ammonia or 3.17 grains muriate of ammonia in 10,000 fluid grains. I also adopt this solution, but have modified the plan of proceeding, it appears to me with advantage. It is thus:

A convenient quantity, 10,000 fluid grains is very suitable, of the water, to which a small quantity of pure hydrochloric acid has been added, is concentrated by a gentle heat to about 1,000 fluid grains: it must of course be slightly acid. This is put into a flask, some excess of pure milk of lime added, and the flask connected by a bent tube with a small Liebig's condenser, to the extremity of which is connected a small Woulfe's bottle, and to this another one furnished at its further neck with a tube containing broken glass moistened with water, this being to prevent escape of ammonia. About half or 500 fluid grains of

product is distilled over and emptied into a tube graduated into 100 divisions of 10 fluid grains each, the bottles washed out with distilled water and added to the tube to make up 100 measures of liquid which is to be thoroughly mixed together. Two wide mouthed bottles or jars of as nearly the same size as possible are provided, into each of which 25 fluid grains of the Hydrarg-Iodide solution is introduced with some distilled water. Then into one of these an aliquot part of the distilled liquid is poured, say $\frac{1}{10}$ or $\frac{1}{4}$, so as to produce a distinct colour, and the bottle is filled up with water. Another similarly graduated tube or burette has been prepared ready filled with the standard solution of muriate of ammonia, and this is carefully added to the second bottle, until the colour produced is as exactly as possible of the same shade as that of the first, both bottles being of course made equally full. The quantity added is then noted, and then calculated on the whole. Thus: suppose 74 fluid grains of the standard solution of muriate of ammonia has been required, this is equal to $74 \times .0001$ grains or .0074 grains ammonia. If 25 measures of the distilled liquor has been used for trial, this is $\frac{1}{4}$th of it, consequently the whole contains $.0074 \times 4 = .0296$ grains ammonia, and as this was from 10,000 fluid grains of water, by consequence the standard quantity of 100,000 fluid grains water contains .296 grains ammonia.

The process requires great care, that there be no accidental admixture of ammonia. The vessels must be scrupulously clean, the distilled water and the lime used must be carefully examined to make sure that they contain no ammonia. The plan of measuring the distillate enables the operator to repeat the trial in case of accident or uncertainty. It is better to work with rather weak colours, as the eye can better detect differences of shade: .0074 grains ammonia is too much for a 2000 grain bottle: any size of bottle may be used, provided the two bottles be as exactly as possible alike in size, shape and capacity.

TABLE IV.

The following table shews the results obtained by this process.

River water of		Ammonia in 100,000 fl. grs.
RAINY SEASON.		grains.
6th July, 1866,		.1133
21st August,		.1825
	Average,	.1429
COLD SEASON.		
9th December, 1865,	Shore,	.0162
Ditto,	Stream,	.0220
Ditto,	ditto,	.0208
27th ditto,	ditto,	.0328
	Average,	.0229
HOT SEASON. *Ebb tide.*		
30th May,		.0250
14th June,		.0189
Ditto repeated,		.0550
	Average,	.0329
Flood Tide.		
30th May,		.0370
14th June,		.1850
Ditto repeated,		.1075
	Average,	.1098

Now on an inspection of this table it will be easily observed that the discrepancies are so great that the results cannot be depended on as at all accurate. I have mentioned the difficulties and nicety of the process, and the errors manifestly point out the necessity of

carefully examining wherein they lie, in order to see if they can be avoided. Yet notwithstanding these inaccuracies, it seems to me that the general results are pretty evident, that the amount of ammonia is greatest in the rainy season, diminishes during the cold one, and again increases during the hot, which increase, however, is probably not in the river water proper. One examination of water from Chandernagore, which was very slightly if at all contaminated with tidal water, yielded only .0118 grain ammonia in 100,000 flood grains. This conclusion is not a certain one; to make it so, it would be necessary to have examinations of the Chandernagore water at all seasons; but other considerations, to be afterwards noticed, render it probable.*

I am disposed to attach a good deal of importance to the estimation of the ammonia, not only because it helps to indicate how far the nitrogenous matter has gone in the stage of decomposition, but because that stage is not improbably one of importance. It has been long known that many, I may say most, of the organic proximate principles found in vegetables are alkaloids possessing active properties and producing the most marked physiological effects, and that there are many similar principles produced in the decomposition of nitrogenised substances by destructive distillation or otherwise, which possess marked physical properties, and probably, if they were examined, also decided physiological actions. But by modern chemical research, it would appear that these alkaloids are all formed on the type of ammonia, or are ammonias having one or more atoms of its hydrogen replaced by some other organic combination or radical. Hence it seems not at all unlikely that such compound ammonias as they are called may be produced at the same time and along with the ultimate or ordinary ammonia. And even though no such compounds should exist, the amount of ammonia would give some probable indication of the stage of decomposition, and existence of compounds is a state of transition towards ammonia.

* The examinations for ammonia were all made about the same time in the month of August, consequently the waters were of different ages. The samples had been preserved mixed with a little Hydrochloric acid and mostly in a concentrated state. Of course objections may be made to their value on this account and possibly may be valid. This will again be referred to in the sequel. 30th November, 1866.

I have seen few published analyses of water indicating the presence or amount of ammonia. Such examinations have been made, but they do not seem to be common. In the case of waters examined for sanitary purposes it appears to me that the point should be attended to. One observation that has come under my notice on the subject is in a paper by Messrs. Lawes and Gilbert on town sewage,* in which is mentioned the quantity of ammonia found in the River Wandle before and after receiving the drainage water from the land irrigated by the sewage of Croydon. In both instances, it amounted to .18 grain per gallon or 70,000 grains, being therefore more than I have found at the worst in the Hooghly water viz. .185 grains per 100,000 grains.

Nitrates.

The presence of nitrates has been more noticed than that of ammonia, though it appears to me less worthy of attention. It is true that they indicate the existence of nitrogenous matter, but it is rather as a thing of the past: the animal matter has been there, but is no longer now, at least that part of it which now has the form of nitric acid; it is now fully oxydized, its animal essence and corruptibility destroyed: it ranks with water and carbonic acid, no longer an organic substance. A process has been devised for estimating small quantities, known as Pugh's process, which Dr. Miller in the above quoted paper recommends for application to water. I have not made use of it, indeed have not had time, but have satisfied myself with some other observations and experiments on the presence of nitrates in the river water. In many instances indeed very distinct deflagration has been observed during ignition of the residue obtained by evaporating the water. This alone does not give good grounds for forming an opinion as to the quantity of the nitrate, as it may be masked or altogether obscured by an excessive proportion of other salts, as of common salt during the hot season. The presence of nitrites can also be observed by the blue colour produced with starch and iodide of potassium by the water acidulated. But as nitrites are simply imperfectly oxydised nitrates, the same observations apply to the former as have been made respecting the latter.

* Journal of the Chemical Society, April, 1866.

I had intended, and still intend, to estimate the quantity of nitric acid for the complete analysis originally contemplated; but for the reasons just stated, I preferred, for the purpose of this communication to direct my attention to other points which appeared of greater importance. That of ammonia which has been just discussed was one of these, and a greater number of determinations of ammonia would have been made, but time did not permit: besides I wished first carefully to examine the ammonia process in order to ascertain the causes of the discrepancies already referred to, with a view to discover the precautions necessary to be taken to ensure more concordant results.

Other nitrogenous matter.

But ammonia and nitric acid are only the ultimate terms of the fermentative and oxydised decomposition of nitrogenous organic matter, and there may be much more present in all stages of decomposition intermediate between these and unchanged animal or vegetable constituents. The amount of these could be estimated by ascertaining the quantity of nitrogen they contain, but the operation is too troublesome to be generally applied to such minute quantities of matter as exists in drinking waters. Animal matters in being ignited or burnt, as is well known, emit a peculiar smell, different from that produced by burning non-nitrogenous substances such as wood, and this has been used as an indication of the presence of, and even as a means of forming a judgment respecting the proportion of matter of animal origin. But it affords a very uncertain means of judging, as even corrupting vegetable matter gives a different smell from fresh, and the peculiar animal odour may be more or less obscured by the greater or less proportion of vegetable matter mixed with the animal. Besides the most characteristic smell given by burning animal matters is that produced by albuminous or gelatinous substances such as muscular fibre, blood, skin, or in short the undecomposed tissues of animal bodies in general. But these substances are probably not to be found in sewage except in small quantity, its constituents are more nearly of the nature of urine and other excrementitious animal matters and the sour products of vegetable decomposition: many of them are volatile and evaporate by a moderate heat with a peculiar

nauseous smell, but one not so characteristic as that produced by burning horn or wool for instance.

Nevertheless not to neglect any means of obtaining information on the subject, I not only, in the course of ascertaining the weight of organic matter by burning it off, paid attention to the appearances then presented, but afterwards made a few experiments on purpose. But with all I cannot concur in the satisfaction expressed by Dr. Angus Smith on the results, as quoted by Dr. Macnamara in his review of the pamphlet.* He speaks of the remarkably clear insight given by boiling down a few thousand grains of water and burning the residue. He says, "We can by the eye and the smell detect humous and peaty acids, nitrogenous organic substances, and nitrates, and estimate their amount to a very useful degree of accuracy. We may even decide by it the animal or vegetable origin of the matter." Now I have carefully evaporated down repeatedly quantities of 50,000 and 100,000 grains of water and attended to these appearances, and the only conclusion I came to was, that the information obtained was very limited and unsatisfactory. I have also varied the experiment and instead of burning the matter in an open platinum crucible have heated it in a glass test tube. For some of the objects in view this is a better plan; and I compared in this way samples of water of the rainy season, of the cold season, and of the hot season during flood tide. For the latter, which is a mixture of river and sea water it is necessary to mix the saline matter with some dry carbonate of soda, or better, to evaporate the water to dryness with this admixture, in order to prevent the evolution of hydrochloric acid vapours. The mouth of the tube is to be loosely closed with a glass stopper which is removed from time to time to examine the smell and try with test papers. Examined in this way, all those samples gave some ammoniacal vapour with no very marked difference; all gave a somewhat urinous animal smell, but not one the characteristic smell of burning flesh or horn: there were slight variations, but none very distinct. The rainy season water gave more of the smell of burning vegetable matter than the others, this being the most distinctive point observed; but altogether the information obtained was very small.

After the failure of all these plans, there remained but one likely to

* Indian Medical Gazette, April, 1866.

be satisfactory, and that was to determine the amount of nitrogen existing in other forms than those of ammonia and nitric acid, this being the only way in which the amount of undecomposed or imperfectly decomposed animal matter can be estimated. The way in which this is usually done is by what is well known to chemists as the soda lime process, and depends on the circumstance that all such animal substances containing nitrogen (this not including nitric acid however), when heated to redness in contact with a hydrated alkali, yield up all their nitrogen combined with hydrogen as ammonia, and this ammonia can by suitable arrangement be collected and its amount ascertained. I am not aware that this plan has been much applied to the examination of animal matter in waters, no doubt on account of the minute quantity of nitrogen present; nevertheless it appeared to me that it might be modified so as to estimate it even in drinking water. I intended to have postponed the trial of this process altogether, as I had not time to make proper arrangements and test the accuracy of the plan. However I made three experiments in a rather hasty and crude manner with such means as I had at hand. They are not at all to be depended on, but I may give the results as obtained.

River water of 2nd June, Ebb, from Chandernagore, containing very little tidal water. 100,000 grains gave .028 grains ammonia.

River water of 21st August, Ebb, from Barnagore. 100,000 grains gave .030 grains ammonia.

River water of May and June, Flood tide, from Barnagore. 100,000 grains gave .010 grains ammonia.

The results, as I have already said, are not to be depended on. Yet it cannot be denied that they are in accordance with the results obtained in other ways, respecting the organic matter. The ready formed ammonia existing in the water had of course been previously removed.

In a practical point of view this portion of the subject is of the principal importance, as more than any other it bears on the question as to how far the river water is contaminated by the sewage of Calcutta. Judging from the results obtained and just mentioned respecting ammonia and fixed nitrogenous organic matter, the amount is not great: even at the highest tide at flood on the 14th June of this year, after twelve months of an unusually small amount of rain-

fall, it is no worse as regards ready formed ammonia than the water of the rainy season; and if the rough experiments on the other nitrogenous matter are to be trusted, it is no worse or not so bad even in this respect; and comparing the results with the one observation quoted respecting the river Wandle as regards ammonia, the Hooghly water even at the worst, has the advantage. In considering this point, it must be borne in mind that the refuse which Calcutta can yield must bear but a very insignificant proportion to the great volume of the waters of the Hooghly compared with that which a large English town will yield to an English river, and more particularly London to the Thames. And then the purifying influences here are so much more active that contaminating constituents are much more speedily destroyed; nature with her all pervading oxygen, its power exalted by a tropical temperature, burning all up. The water of the stream in constant motion presents perpetually renewed surfaces to the atmosphere to absorb the great purifying agent, and the importance of this will perhaps be more clearly manifested by comparison with another class of waters with which I shall conclude this paper.

Tank Waters.

This class is the tank waters, a few of which I have made a partial examination of, for the purpose of comparison. These are General's tank, near the entrance to Park Street; Monohor Doss' tank, near that to Lindsay Street, both of them on the plain round the Fort; Dalhousie Square tank, supplied by the river; Cornwallis Square Tank, at the northern part of the town; a newly cleaned and dug out tank at Dhurrumtollah (supplied by Mr. Dall); and a village tank near my own premises. Also I have examined slightly two well waters, and the water of the Salt Water Lake to the east of the town; the results of all will be given in one table and a few remarks appended afterwards.

The water of the two tanks from the plain in May and June had a slightly putrid flavour; in August this was much less. Cornwallis Square tank was very low in May and putrid, had not increased very much in August and was still bad. The Dhurrumtollah tank was bad flavoured and abounded in vegetation; the Barnagore tank in May and June was covered with a thick coat of floating vegetation, and was very dirty and bad smelled, quite unfit for use even by the villagers. In August during the rains its appearance improved somewhat.

Table V.

For 100,000 fluid grains.

	Date of collecting.	Solid matter.	Organic matter.	Oxygen reqd. to oxidise.	Ammonia.
	1866.				
General's Tank, ...	6 June,	12.05	1.35	.0825	.235
	14 Aug.			.1225	
Monohur Doss's Tank, ...	14 May,	24.60	2.00	.0913	
	6 June,			.1000	
	14 Aug.			.1400	.204
Dalhousie Square Tank, ...	14 May,	23.85	1.50		
	6 June,	25.80		.0750	
Cornwallis Square Tank, ...					
settled and veg. matter deposited, ...	14 May,	58.00	4.40	.1550	
not settled, ...	14 Aug.		5.15		
Dhurrumtollah Tank, ...	Aug.			.2975	.237
Barnagore, ...	11 May,	51.00	4.25	.3170	
	8 June,			.2938	
	17 Aug.			.3375	
Dhurrumtollah well, ...	Aug.			.0725	
Barnagore well, ...	18 Aug.			.0900	
Salt Water Lake, from Canal at Dhappa Toll House, ...	13 June,	908.00	20.00	.1250	
Ditch conveying sewerage of Calcutta, ...	1 June,	295.80	33.10	5.680	
* Ditto, ...	8 Sept.		27.33		
* Ditto, ..	13 Sept.		22.25		

On examining this table, it will be observed that even the best tank water contains more organic matter by weight, and requires more oxygen to oxydise it than does the river water during ebb tide; even Dalhousie Square water appears to deteriorate by being removed from the running stream into a stagnant reservoir. The excess of organic matter in the bad tanks is also very noticeable. The two well waters require more oxygen than the river water generally.

* Added since the date of the paper.

The Salt Water Lake water did not require more oxygen than the tank waters.*

I have little to add in the way of concluding remarks, as my object was not to report on any scheme or recommend any plan, but simply to communicate to a scientific society the results of numerous experiments and observations on a subject of practical importance. Some of these investigations are defective, but I intend to endeavour to remedy these defects by further investigation. And even after these are remedied, the results may indicate that there are yet other points o examine. There is work for the naturalist in the investigation of he animal and vegetable life in such waters, possibly exercising as great an influence on their salubrity as their chemical composition. Yet even this can only be aided by a full and accurate knowledge of their chemical constituents. There are also questions connected with the preservation and use of the water, and these too are more likely to be correctly answered, the more complete is our knowledge of the nature of its composition.

But I may briefly sum up the conclusions arrived at with reference to the application of the Hooghly water to the supply of the wants of Calcutta. As regards its inorganic constituents, the Hooghly water taken near Calcutta is at least as pure as any of the waters supplied to London, or indeed generally more pure for about eight or nine months of the year; during the hot season it is mixed with sea water under the influence of the tides and thereby rendered brackish. This can be avoided by taking the supply of water from further up the river.

As regards organic matter, again, my results, if correct, indicate that the state of the water seems to be worst during the rainy season, and that notwithstanding the influence of the tides and the sewerage of Calcutta, it is doubtful if even at the hottest part of the hot season in June its impurity equals that of the water during the rains; and it is

* I have already stated that it was with considerable hesitation that I left the indications of the permanganate Test in table III. on account of the objections raised to their value: similar hesitation was felt as to inserting Table IV. and it was the indications given in Table V. which determined me to retain them. The same objections indeed apply to the results shewn by it, but this does not materially affect the purpose for which it is introduced. It will serve sufficiently well for purposes of general comparison, the trials for oxidizable matter and ammonia having been made at the same times on both river and tank waters, so that generally both kinds were of the same age or nearly so. More exact determinations will be made in future. 30th Nov. 1866.

questionable if even in the nature or quality of the organic impurities it is worse. Now as it is not likely that during the rains the water is materially different at Barrackpore from what it is at Calcutta, there will be little or nothing gained by taking it from Barrackpore during these months, the chief advantage being therefore that the salt water of the hot season will be avoided. Still even as it is, there seems to be no better source; for the organic impurities of the tank waters, even the best of them, seem at least equal in amount to those of the river water during flood tide, and greater than the same during ebb tide. And so far as a judgment can be formed from the means of comparison within reach, the water during the rains probably contains less organic impurity than the London waters.*

Such are the conclusions I have arrived at, some of them unexpected even to myself, and which may be disputed by others. They are of course open to criticism and discussion. They may be suggestive of other things possibly of practical application, but into these I have not yet had time to enter.

* I have much doubt upon these points, as much of the organic matter of the rainy season is probably adherent to the finely divided mud in suspension in the water, which is so difficult to separate. With a view to the use of the water, the point would require to be investigated in connection with the process to be employed for the purification of the water. Judgment may be considered suspended on them, more particularly on that of the purity of the water of the *best* tanks at all seasons of the year, and of the nature and amount of the organic matter of the river water during the rainy season. Further remarks will be made on these subjects in subsequent communications. 30th Nov. 1866.

Granite ....

Metamorphic ....

Volcanic ....

Silurian ....

Carboniferous ....

Saliferian (Permian or Triassic ?) ....

Jurassic (Middle Oolite) ....

Nummulitic ....

Miocene (perhaps the Upp[illegible] his Older-Pliocene) ....

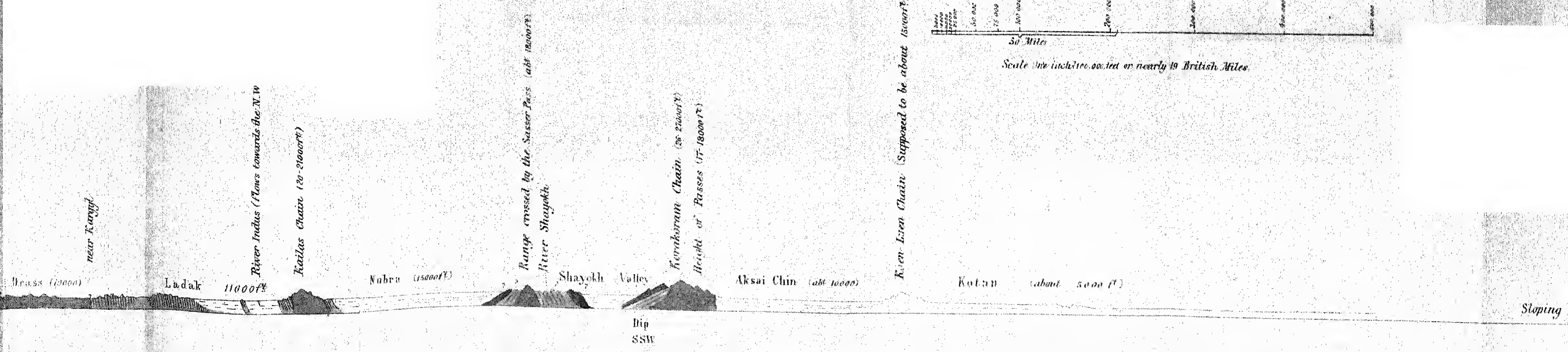
New (perhaps Post - Pliocene) ....

Sloping towards the Swamps of the Zarrah Lake & the deserts of Ea

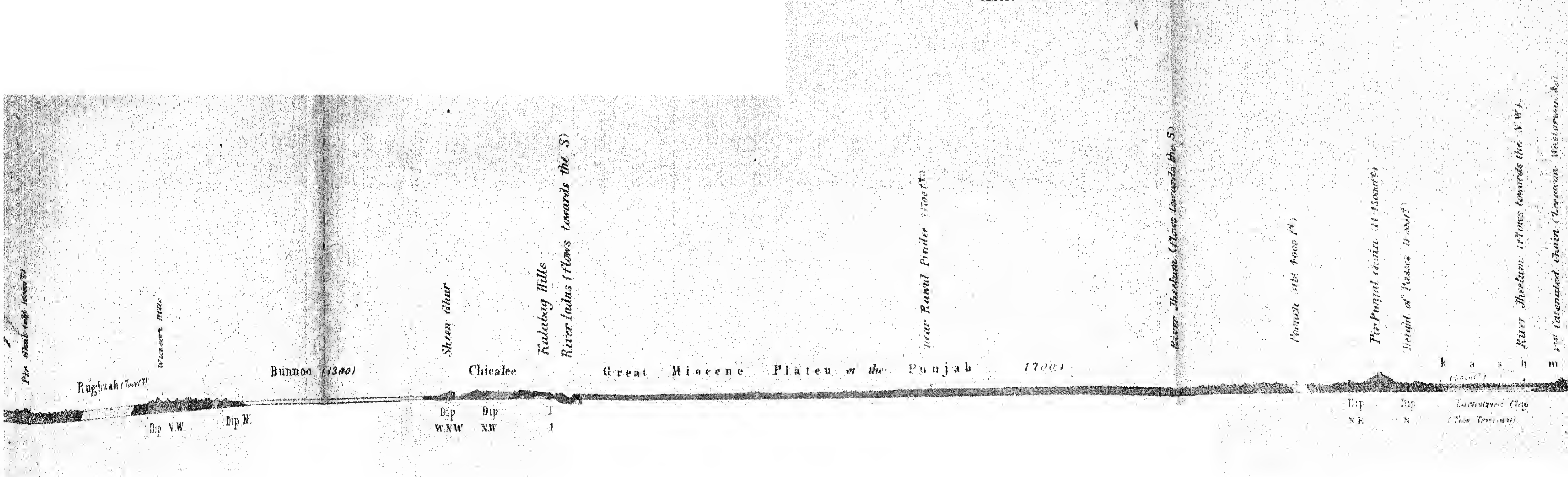
Journal As. Soc. Vol. XXXV Pl. II.

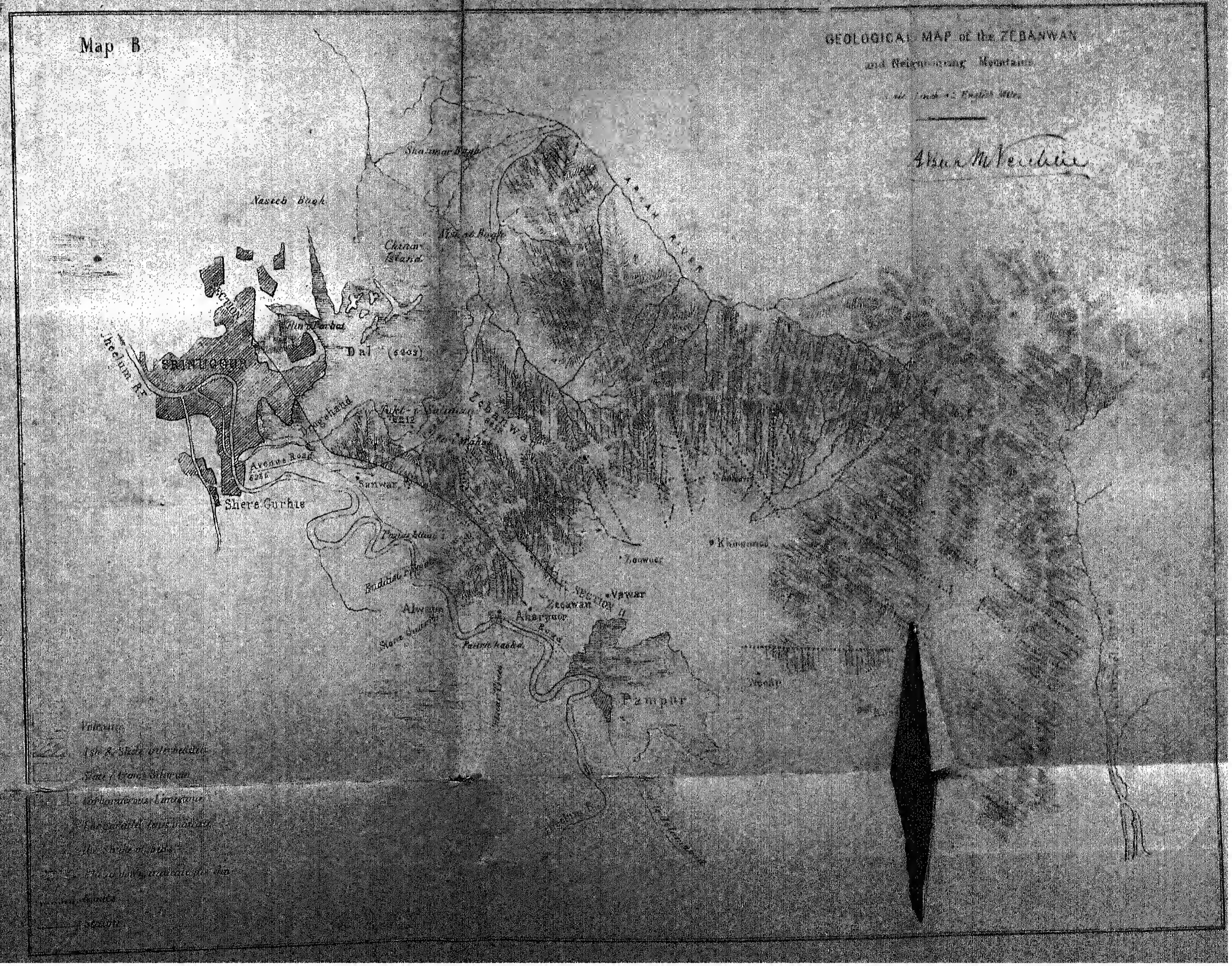
Section G.

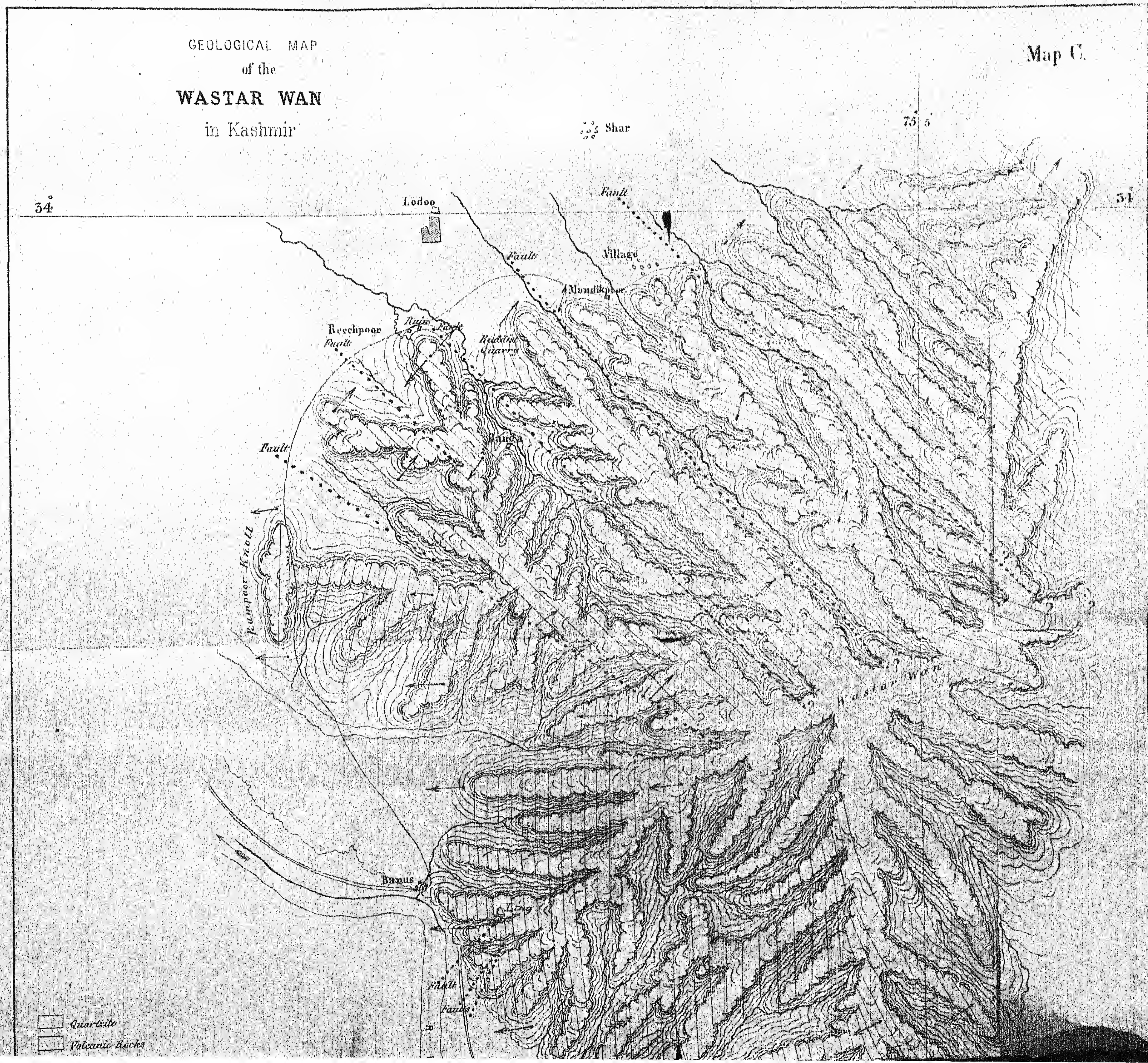
(or General Section

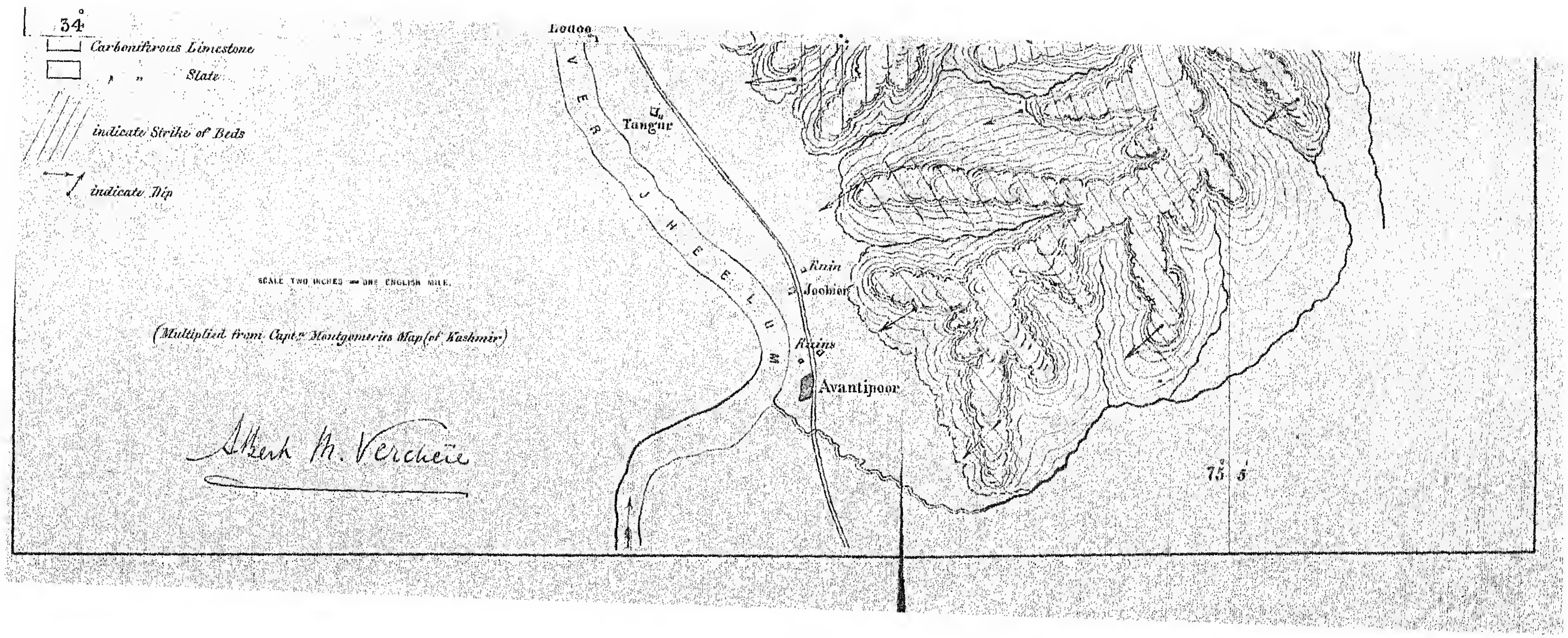


SECTION ACROSS the WESTERN HIMALAYA, the GREAT PUNJAB MIOCENE PLATEAU and the AFGHAN MOU




Map B
GEOLOGICAL MAP of the ZEBANWAN
Shalimar Bagh
Naseeb Bagh
Chinar Island
Dal (5603)
SRINUGGUR
Jhelum R.
Avenue Road
Shere Gurhie
Sunwar
Zeewan
Vawar
Khunmoo
Akarpoor
Pampur
Volcanic
Section


GEOLOGICAL MAP
of the
WASTAR WAN
in Kashmir
Map C.
75 5'
Shar
34°
34
Lodoo
Fault
Village
Mundikpoor
Reechpoor
Ruin
Fault
Buddist Quarry
Fault
Rampoor Knoll
Wastar Wan
Banus
Fault
Quartzite
Volcanic Rocks


34°
Carboniferous Limestone
" " Slate
indicate Strike of Beds
indicate Dip
SCALE TWO INCHES = ONE ENGLISH MILE.
(Multiplied from Captn. Montgomerie's Map of Kashmir)
Lodoo
Tangur
RIVER JHEELUM
Ruin
Joobier
Ruins
Avantipoor
75° 5'

Sea level

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of January, 1866.

Latitude 22° 23′ 1″ North. Longitude 88° 20′ 34″ East.

Height of the Cistern of the Standard Barometer above the Sea-level, 18 ft. 11 in.

Daily Means, &c. of the Observations and of the Hygrometrical elements dependent thereon.

Date.	Mean Height of the Barometer at 32° Faht.	Range of the Barometer during the day.			Mean Dry Bulb Thermometer.	Range of the Temperature during the day.		
		Max.	Min.	Diff.		Max.	Min.	Diff.
	Inches.	Inches.	Inches.	Inches.	o	o	o	o
1	30.056	30.147	30.006	0.141	68.3	76.4	61.0	15.4
2	.045	.134	29.993	.141	68.0	77.8	60.4	17.4
3	.029	.113	.987	.126	69.1	79.4	60.2	19.2
4	.001	.082	.930	.152	72.0	82.8	62.8	20.0
5	29.961	.061	.886	.175	73.4	83.6	65.8	17.8
6	.906	29.971	.848	.123	73.1	81.2	66.4	14.8
7	30.007	30.073	.948	.125	68.4	73.8	64.6	9.2
8	.113	.221	30.057	.164	64.0	73.0	55.8	17.2
9	.119	.219	.064	.155	63.4	72.9	56.0	16.9
10	.068	.158	.004	.154	65.2	75.5	57.6	17.9
11	.042	.112	29.992	.120	66.9	77.0	58.6	18.4
12	.068	.158	30.003	.155	66.1	76.6	57.0	19.6
13	.060	.140	.015	.125	65.5	76.8	56.0	20.8
14	.060	.133	29.995	.138	67.8	79.0	58.0	21.0
15	.082	.183	30.019	.164	68.8	78.6	60.0	18.6
16	.036	.123	29.969	.154	67.5	77.2	59.2	18.0
17	.012	.098	.955	.143	67.1	77.4	58.9	18.5
18	.018	.107	.959	.148	68.2	78.7	59.2	19.5
19	29.990	.056	.923	.133	69.9	81.4	61.0	20.4
20	30.028	.106	.967	.139	70.1	81.2	61.0	20.2
21	.044	.113	.962	.151	71.3	81.0	62.6	18.4
22	.080	.161	30.033	.128	73.1	81.3	65.0	16.3
23	.096	.165	.029	.136	70.5	79.8	62.2	17.6
24	.105	.185	.020	.165	71.6	81.2	62.8	18.4
25	.077	.148	29.989	.159	73.1	82.0	64.4	17.6
26	.085	.173	30.013	.160	74.5	83.8	66.4	17.4
27	.066	.152	29.983	.169	74.0	84.7	67.0	17.7
28	.042	.083	30.001	.082	68.3	77.8	63.4	14.4
29	.005	.079	29.935	.144	68.6	75.2	63.4	11.8
30	29.975	.056	.929	.127	68.2	72.2	63.8	8.4
31	30.003	.094	.937	.157	63.4	64.6	62.2	2.4

The Mean Height of the Barometer, as likewise the Dry and Wet Bulb Thermometer Means are derived, from the hourly observations made, during the day.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of January, 1866.

Daily Means, &c. of the Observations and of the Hygrometrical elements dependent thereon.—*Continued.*

Date.	Mean Wet Bulb Thermometer.	Dry Bulb above Wet.	Computed Dew Point.	Dry Bulb above Dew Point.	Mean Elastic force of vapour.	Mean Weight of Vapour in a Cubic foot of air.	Additional Weight of Vapour required for complete saturation.	Mean degree of Humidity, complete saturation being unity.
	o	o	o	o	Inches.	T. gr.	T. gr.	
1	62.5	5.8	57.9	10.4	0.468	5.38	2.22	0.71
2	61.8	6.2	56.8	11.2	.470	.19	.34	.69
3	63.2	5.9	58.5	10.6	.498	.48	.30	.70
4	67.3	4.7	63.5	8.5	.588	6.43	.07	.76
5	68.2	5.2	64.0	9.4	.597	.53	.34	.74
6	68.2	4.9	64.3	8.8	.603	.60	.19	.75
7	62.2	6.2	57.2	11.2	.476	5.25	.37	.69
8	56.8	7.2	50.3	13.7	.377	4.20	.45	.63
9	57.3	6.1	51.8	11.6	.397	.42	.11	.68
10	58.7	6.5	53.5	11.7	,421	.68	.23	.68
11	60.3	6.6	55.0	11.9	.442	.90	.38	.67
12	58.8	7.3	53.0	13.1	.414	.59	.51	.65
13	58.4	7.1	52.7	12.8	.409	.55	.43	.65
14	62.1	5.7	57.5	10.3	.481	5.32	.16	.71
15	61.8	7.0	56.2	12.6	.461	.07	.64	.66
16	60.5	7.0	54.9	12.6	.441	4.87	.55	.66
17	60.6	6.5	55.4	11.7	.449	.96	.36	.68
18	61.1	7.1	55.4	12.8	.449	.95	.63	.65
19	64.4	5.5	60.0	9.9	.523	5.75	.23	.72
20	64.1	6.0	59.3	10.8	.511	.61	.42	.70
21	66.7	4.6	63.0	8.3	.578	6.35	1.98	.76
22	65.6	7.5	59.6	13.5	.516	5.64	3.15	.64
23	63.1	7.4	57.2	13.3	.476	.23	2.90	.64
24	64.2	7.4	58.3	13.3	.494	.42	.98	.65
25	67.2	5.9	62.5	10.6	.568	6.21	.58	.71
26	69.5	5.0	66.0	8.5	.638	.95	.23	.76
27	69.3	4.7	66.0	8.0	.638	.97	.07	.77
28	65.5	2.8	63.3	5.0	.584	.44	1.16	.85
29	66.5	2.1	64.8	3.8	.613	.78	0.89	.88
30	66.2	2.0	64.6	3.6	.609	.73	.85	.89
31	61.8	1.6	60.4	3.0	.530	5.91	.62	.91

All the Hygrometrical elements are computed by the Greenwich Constants.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of January, 1866.

Hourly Means, &c. of the Observations and of the Hygrometrical elements dependent thereon.

Hour.	Mean Height of the Barometer at 32° Faht.	Range of the Barometer for each hour during the month.			Mean Dry Bulb Thermometer.	Range of the Temperature for each hour during the month.		
		Max.	Min.	Diff.		Max.	Min.	Diff.
	Inches.	Inches.	Inches.	Inches.	o	o	o	o
Mid-night.	30.046	30.119	29.921	0.198	65.5	72.4	60.0	12.4
1	.039	.113	.902	.211	64.8	72.4	58.8	13.6
2	.030	.106	.886	.220	64.2	72.0	57.8	15.2
3	.021	.099	.867	.232	63.6	71.8	57.4	14.4
4	.014	.094	.848	.246	62.9	70.4	57.0	13.4
5	.022	.103	.861	.242	62.3	69.7	56.4	13.3
6	.038	.120	.867	.253	62.1	69.5	55.8	13.7
7	.059	.156	.885	.271	61.8	67.4	56.0	11.4
8	.088	.190	.927	.263	63.7	69.2	57.8	11.4
9	.114	.215	.957	.258	67.2	73.2	61.2	12.0
10	.122	.221	.971	.250	70.8	77.7	63.8	13.9
11	.105	.197	.960	.237	73.2	79.4	63.6	15.8
Noon.	.075	.167	.935	.232	75.2	81.6	62.6	19.0
1	.035	.124	.897	.227	76.5	82.8	62.4	20.4
2	.007	.091	.871	.220	77.5	84.0	62.8	21.2
3	29.989	.077	.861	.216	78.0	84.7	63.8	20.9
4	.983	.064	.851	.213	76.8	82.8	64.4	18.4
5	.992	.077	.864	.213	75.5	81.5	63.8	17.7
6	.999	.076	.880	.196	72.6	79.2	62.6	16.6
7	30.018	.088	.904	.184	70.9	77.0	62.8	14.2
8	.035	.109	.929	.180	69.5	75.3	62.8	12.5
9	.050	.121	.941	.180	68.1	74.1	62.6	11.5
10	.056	.137	.940	.197	67.0	73.4	61.8	11.6
11	.052	.132	.927	.205	66.1	72.5	60.6	11.9

The Mean Height of the Barometer, as likewise the Dry and Wet Bulb Thermometer Means are derived from the Observations made at the several hours during the month.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of January, 1866.

Hourly means, &c. of the Observations and of the Hygrometrical elements dependent thereon.—*(Continued.)*

Hour.	Mean Wet Bulb Thermometer.	Dry Bulb above Wet.	Computed Dew Point.	Dry Bulb above Dew Point.	Mean Elastic force of Vapour.	Mean Weight of Vapour in a Cubic foot of air.	Additional Weight of Vapour required for complete saturation.	Mean degree of Humidity, complete saturation being unity.
	o	o	o	o	Inches.	T. gr.	T. gr.	
Midnight.	62.1	3.4	59.4	6.1	0.513	5.69	1.29	0.82
1	61.7	3.1	59.2	5.6	.509	.66	.17	.83
2	61.2	3.0	58.5	5.7	.498	.53	.16	.83
3	60.7	2.9	58.1	5.5	.491	.46	.11	.83
4	60.2	2.7	57.8	5.1	.486	.43	.00	.84
5	59.7	2.6	57.4	4.9	.480	.36	0.95	.85
6	59.7	2.4	57.5	4.6	.481	.38	.89	.86
7	59.4	2.4	57.2	4.6	.476	.32	.89	.86
8	60.7	3.0	58.0	5.7	.489	.44	1.15	.83
9	62.7	4.5	59.1	8.1	.508	.62	.73	.77
10	64.4	6.4	59.3	11.5	.511	.60	2.60	.68
11	65.3	7.9	59.0	14.2	.506	.53	3.29	.63
Noon.	65.9	9.3	59.4	15.8	.513	.58	.79	.60
1	66.3	10.2	59.2	17.3	.509	.54	4.21	.57
2	66.7	10.8	59.1	18.4	.508	.50	.54	.55
3	66.8	11.2	59.0	19.0	.506	.47	.72	.54
4	66 2	10.6	58.8	18.0	.503	.45	.38	.55
5	65.9	9.6	59.2	16.3	.509	.55	3.91	.59
6	65.8	6.8	60.4	12.2	.530	.81	2.85	.67
7	65.1	5.8	60.5	10.4	.532	.85	.38	.71
8	64.4	5.1	60.3	9.2	.528	.82	.06	.74
9	63.7	4.4	60.2	7.9	.527	.82	1.73	.77
10	63.1	3.9	60.0	7.0	.523	.79	.51	.79
11	62.5	3.6	59.6	6.5	.516	.72	.38	.81

All the Hygrometrical elements are computed by the Greenwich Constants.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of January, 1866.

Solar Radiation, Weather, &c.

Date.	Max. Solar radiation.	Rain Guage 5 feet above Ground.	Prevailing direction of the Wind.	General Aspect of the Sky.
	o	Inches		
1	138.0	...	N. & W. & N. W.	Clear, slightly foggy at midnight & 1 A. M. and from 8 to 11 P. M.
2	134.0	...	N. & W.	Clear, slightly foggy from 8 to 10 P. M.
3	134.0	...	S. W. & S.	Clear, slightly foggy at 1 A. M.
4	138.4	...	S.	Clear to 8 P. M. Scatd. ╲i afterwards.
5	139.0	...	S.	╲i to 8 A. M. ╲—i to 4 P. M. clear afterwards.
6	129.5	...	S. & variable.	Clear to 9 A. M. Scatd. ⌒i afterwards, slightly foggy at 5 A. M.
7	139.0	...	N. & N. W.	Various clouds to 7 A. M., clear afterwards.
8	129.0	...	N. & N. W.	Clear.
9	124.8	...	N. & N. W.	Clear.
10	131.0	...	N. W. & N.	Clear, slightly foggy from 8 to 10 P. M.
11	133.2	...	W.	Clear, slightly foggy at 9 P. M.
12	131.0	...	N. W. & N. & N. E.	Clear.
13	129.0	...	W. & N. E. & N.	Clear.
14	133.4	...	W. & variable.	Clear, foggy at 5 and 6 A. M.
15	133.0	...	N. & N. E.	Clear to 10 A. M. Scatd. ╲i to 5 P. M. clear afterwards, slightly foggy at 10 & 11 P. M.
16	126.0	..	N. & S.	Clear to 6 A. M. Scatd. ╲i to 11 A. M., clear afterwards.
17	129.0	...	N. & W. & N. W.	Clear to 9 A. M. Scatd. ╲i to 6 P. M. clear afterwards.
18	130.8	...	W.	Clear, slightly foggy at 6 A. M.
19	129.5	...	S. & N.	Clear to 5 A. M. ⌒i to 6 P. M. clear afterwards.
20	134.5	...	E. & N. E.	Clear, slightly foggy from 5 to 9 A. M.
21	130.0	...	S. W. & W.	Clear to noon, Scatd. ⌒i to 4 P. M. clear afterwards.
22	134.0	...	N.	Clear, foggy from 2 to 4 A. M.
23	127.2	...	W. & N.	Clear to Noon, Scatd. ╲i to 5 P. M. clear afterwards, slightly foggy from 8 to 11 P. M.
24	130.8	...	W.	Clear to 3 P. M. Scatd. ╲i to 8 P. M. clear afterwards, slightly foggy at 7 & 8 P. M.
25	135.2	...	W. & S. W.	Clear to 10 A. M. Scatd. ⌒i to 7 P. M. Scatd. ╲—i afterwards.

╲i Cirri, —i Strati, ⌒i Cumuli, ╲—i Cirro-strati, ⌒—i Cumulo-strati, ╲╱—i Nimbi, ╲⌒i Cirro-cumuli.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of January, 1866.

Solar Radiation, Weather, &c.

Date.	Max. Solar radiation.	Rain Guage 5 feet above Ground.	Prevailing direction of tion Wind.	General Aspect of the Sky.
	o	Inches		
26	139.5	...	E. & S. & W.	Clear to 5 A. M. Scatd. ⌒i afterwards.
27	129.5	...	S.	Scatd. ⌒i to 7 P. M. clear afterwards, slightly foggy at 7 A. M. and thin rain at 6 P. M.
28	...	0.45	E. & S. E.	Clear to 10 A. M. Overcast to 6 P. M. ⌒i afterwards rain between 1 & 2 P. M. and from 4 to 6 P. M. Thunder at 3 & 5 P. M.
29	...	0.80	S. E. & S.	Overcast. Lightning towards N. at 8 & 9 P. M. rain after intervals.
30	...	0.20	N.	Scatd. ⌒i to 5 A. M. overcast to 11 A. M. ⌒i to 3 P. M. overcast afterwards. Light rains from 7 to 10 A. M. and from 5 to 9 P. M.
31	...	0.46	N. & N. E.	Overcast, rain at 4, 8, 9, 11 and Noon.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of January, 1866.

Monthly Results.

	Inches
Mean height of the Barometer for the month,...	30.041
Max. height of the Barometer occurred at 10 A. M. on the 8th, ...	30.221
Min. height of the Barometer occurred at 4 A. M. on the 6th, ...	29.848
Extreme Range of the Barometer during the month, ...	0.373
Mean of the daily Max. Pressures, ...	30.123
Ditto ditto Min. ditto	29.979
Mean daily range of the Barometer during the month, ...	0.144

	o
Mean Dry Bulb Thermometer for the month, ...	69.0
Max. Temperature occurred at 3 P. M. on the 27th, ...	84.7
Min. Temperature occurred at 6 A. M. on the 8th, ...	55.8
Extreme range of the Temperature during the month, ...	28.9
Mean of the daily Max. Temperature, ...	78.2
Ditto ditto Min. ditto, ...	61.4
Mean daily range of the Temperature during the month, ...	16.8

Mean Wet Bulb Thermometer for the month, ...	63.4
Mean Dry Bulb Thermometer above mean Wet Bulb Thermometer, ...	5.6
Computed Mean Dew-point for the month, ...	58.9
Mean Dry Bulb Thermometer above computed mean Dew-point, ...	10.1
	Inches
Mean Elastic force of Vapour for the month, ...	0.504

	Troy grains
Mean Weight of Vapour for the month, ...	5.56
Additional Weight of Vapour required for complete saturation, ...	2.20
Mean degree of humidity for the month, complete saturation being unity,	0.72

	Inches
Rained 5 days, Max. fall of rain during 24 hours, ...	0.80
Total amount of rain during the month, ...	1.91
Total amount of rain indicated by the Gauge attached to the Anemometer during the month, ...	1.70
Prevailing direction of the Wind, ...	N. & W. & S.

Abstract of the Results of ths Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of January, 1866.

Monthly Results.

Tables showing the number of days on which at a given hour any particular wind blew, together with the number of days on which at the same hour, when any particular wind was blowing, it rained.

Hour.	N.	Rain on.	N. E.	Rain on.	E.	Rain on.	S. E.	Rain on.	S.	Rain on.	S. W.	Rain on.	W.	Rain on.	N. W.	Rain on.	Calm.	Rain on.	Missed.
								No. of days.											
Midnight,	7		4		2		3		6				9						
1	9		3		3		2		6				8						
2	9		4		1		1		9				7						
3	11		2		4		1		7		2		4						
4	11		3		4	1			7		1		4		1	1			
5	11		3		3				6		2		4		1	1			1
6	11		6		2				6		2		4						
7	10	1	3		5		2		3		2		4		2				
8	11	2	1		7		2		2		3		3		2				
9	12	2	4		3		4		2		2		3		1				
10	10	1	5		3		4	1	2		2		4		1				
11	8	1	4		2				6		1		2		8				
Noon.	13	1	3				1	1	6		1				7				
1	11		2		1				4	1	3		3		7				
2	1		3		3	1			3		3		7		11				
3	3		2		1				4		1		7		13				
4	5		1		2	1			3		2		10		8				
5	7	2			1				4				10		9				
6	8	2			1	1			5				12		5				
7	9		1		2		2		3		1		10		3				
8	9	1	2		1		2		2		2		10		3				
9	9	1	1		2		1		3		1		11		3				
10	7		3	1	2		2		4		2		8		3				
11	7	1	3		2		3		6		1		8		1				

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of February, 1866.

Latitude 22° 23′ 1″ North. Longitude 88° 20′ 34″ East.

Height of the Cistern of the Standard Barometer above the Sea-level, 18 ft. 11 in.

Daily Means, &c. of the Observations and of the Hygrometrical elements dependent thereon.

Date.	Mean Height of the Barometer at 32° Faht.	Range of the Barometer during the day.			Mean Dry Bulb Thermometer.	Range of the Temperature during the day.		
		Max.	Min.	Diff.		Max.	Min.	Diff.
	Inches.	Inches.	Inches.	Inches.	o	o	o	o
1	29.982	30.052	29.934	0.118	63.1	66.9	60.0	6.9
2	.994	.067	.946	.121	64.3	71.6	58.4	13.2
3	.921	.013	.840	.173	65.3	73.8	57.2	16.6
4	.833	29.898	.787	.111	63.6	70.6	60.4	10.2
5	.848	.925	.766	.159	66.3	75.8	58.6	17.2
6	.983	30.062	.915	.147	69.2	78.4	61.8	16.6
7	30.045	.138	.985	.153	70.5	80.2	61.4	18.8
8	.024	.101	.967	.134	70.8	80.4	63.0	17.4
9	.060	.132	.997	.135	68.1	75.2	64.6	10.6
10	.051	.122	.982	.140	71.5	81.7	62.0	19.7
11	29.987	.041	.915	.126	69.9	80.0	65.4	14.6
12	.943	.013	.850	.163	66.8	71.2	62.4	8.8
13	30.037	.124	.986	.138	63.8	71.1	56.4	14.7
14	.006	.075	.937	.138	64.7	73.5	56.2	17.3
15	29.975	.057	.919	.138	67.3	76.4	58.6	17.8
16	.952	.040	.888	.152	69.3	78.4	59.8	18.6
17	.966	.046	.925	.121	72.6	82.0	63.2	18.8
18	.981	.073	.930	.143	72.8	78.3	68.8	9.5
19	.981	.062	.886	.176	74.9	86.0	67.4	18.6
20	.953	.039	.896	.143	71.9	80.2	67.8	12.4
21	.945	.023	.897	.126	73.7	81.8	67.8	14.0
22	.923	29.992	.856	.136	72.0	81.0	63.2	17.8
23	.945	30.021	.894	.127	72.7	82.6	62.2	20.4
24	.967	.056	.916	.140	73.0	84.8	62.8	22.0
25	.937	.009	.874	.135	75.1	87.2	64.8	22.4
26	.887	29.959	.824	.135	77.0	88.2	67.5	20.7
27	.843	.914	.791	.123	77.9	89.2	68.4	20.8
28	.815	.900	736	.164	79.6	91.4	70.8	20.6

The Mean Height of the Barometer, as likewise the Dry and Wet Bulb Thermometer Means are derived from the hourly observations made during the day.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of February, 1866.

Daily Means, &c. of the Observations and of the Hygrometrical elements dependent thereon.—*Continued.*

Date.	Mean Wet Bulb Thermometer.	Dry Bulb above Wet.	Computed Dew Point.	Dry Bulb above Dew Point.	Mean Elastic force of vapour.	Mean Weight of Vapour in a Cubic foot of air.	Additional Weight of Vapour required for complete saturation.	Mean degree of Humidity, complete saturation being unity.
	o	o	o	o	Inches.	T. gr.	T. gr.	
1	61.4	1.7	59.9	3.2	0.521	5.81	0.66	0.90
2	59.3	5.0	54.8	9.5	.440	4.88	1.84	.73
3	59.9	5.4	55.6	9.7	.452	5.02	.91	.72
4	59.9	3.7	56.6	7.0	.467	.21	.36	.79
5	61.7	4.6	58.0	8.3	.489	.42	.73	.76
6	63.5	5.7	58.9	10.3	.504	.56	2.25	.71
7	62.6	7.9	56.3	14.2	.462	.08	3.05	.63
8	64.0	6.8	58.6	12.2	.499	.49	2.71	.67
9	63.9	4.2	60.5	7.6	.532	.87	1.68	.78
10	65.9	5.6	61.4	10.1	.548	6.02	2.36	.72
11	65.6	4.3	62.2	7.7	.563	.19	1.79	.78
12	62.8	4.0	59.6	7.2	.516	5.72	.54	.79
13	56.2	7.6	49.4	14.4	.366	4.08	2.53	.62
14	58.8	5.9	54.1	10.6	.429	.77	.03	.70
15	60.8	6.5	55.6	11.7	.452	5.00	.37	.68
16	62.9	6.4	57.8	11.5	.486	.35	.48	.68
17	67.8	4.8	64.0	8.6	.597	6.53	.13	.75
18	70.2	2.6	68.1	4.7	.684	7.47	1.24	.86
19	68.4	6.5	63.8	11.1	.593	6.46	2.82	.70
20	67.5	4.4	64.0	7.9	.597	.54	1.94	.77
21	66.3	7.4	61.1	12.6	.543	5.92	3.04	.66
22	62.9	9.1	55.6	16.4	.452	4.96	.54	.58
23	62.7	10.0	54.7	18.0	.438	.79	.89	.55
24	62.9	10.1	54.8	18.2	.440	.80	.96	.55
25	64.9	10.2	57.8	17.3	.486	5.29	4.05	.57
26	67.3	9.7	60.5	16.5	.532	.77	.12	.58
27	69.8	8.1	64.1	13.8	.599	6.48	3.68	.64
28	73.2	6.4	68.7	10.9	.697	7.52	.17	.70

All the Hygrometrical elements are computed by the Greenwich Constants.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of February, 1866.

Hourly Means, &c. of the Observations and of the Hygrometrical elements dependent thereon.

Hour.	Mean Height of the Barometer at 32° Faht.	Range of the Barometer for each hour during the month.			Mean Dry Bulb Thermometer.	Range of the Temperature for each hour during the month.		
		Max.	Min.	Diff.		Max.	Min.	Diff.
	Inches.	Inches.	Inches.	Inches.	o	o	o	o
Mid-night.	29.964	30.079	29.831	0.248	66.3	74.2	59.8	14.4
1	.954	.070	.821	.249	65.8	74.0	59.0	15.0
2	.943	.051	.794	.257	65.2	74.0	58.7	15.3
3	.931	.046	.778	.268	64.6	73.5	58.0	15.5
4	.925	.039	.766	.273	64.1	72.4	57.4	15.0
5	.936	.071	.797	.274	63.7	71.6	56.8	14.8
6	.954	.079	.827	.252	63.3	71.2	56.6	14.6
7	.974	.085	.845	.240	63.3	70.8	56.2	14.6
8	30.000	.106	.868	.238	65.6	71.0	58.8	12.2
9	.026	.132	.898	.234	68.9	75.2	60.6	14.6
10	.031	.138	.883	.255	71.6	78.6	60.8	17.8
11	.021	.127	.884	.243	74.0	82.0	62.0	20.0
Noon.	29.994	.099	.847	.252	76.1	86.4	62.9	23.5
1	.962	.063	.813	.250	77.4	88.8	65.0	23.8
2	.931	.028	.778	.250	78.3	90.6	66.8	23.8
3	.911	.012	.748	.264	78.6	91.4	64.4	27.0
4	.905	.022	.740	.282	77.9	91.2	63.8	27.4
5	.907	.062	.736	.326	77.0	90.6	62.8	27.8
6	.915	.070	.742	.328	74.6	87.6	62.5	25.1
7	.929	.111	.760	.351	72.6	84.6	62.2	22.4
8	.948	.122	.784	.338	70.9	80.6	62.0	18.6
9	.962	.117	.798	.319	69.7	78.4	62.1	16.3
10	.969	.080	.809	.271	68.6	77.2	61.8	15.4
11	.964	.071	.804	.267	67.6	76.0	61.4	14.6

The Mean Height of the Barometer, as likewise the Dry and Wet Bulb Thermometer Means are derived from the Observations made at the several hours during the month.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of February, 1866.

Hourly means, &c. of the Observations and of the Hygrometrical elements dependent thereon.—*(Continued.)*

Hour.	Mean Wet Bulb Thermometer.	Dry Bulb above Wet.	Computed Dew Point.	Dry Bulb above Dew Point.	Mean Elastic force of Vapour.	Mean Weight of Vapour in a Cubic foot of air.	Additional Weight of Vapour required for complete saturation.	Mean degree of Humidity, complete saturation being unity.
	o	o	o	o	Inches.	T. gr.	T. gr.	
Midnight.	62.9	3.4	60.2	6.1	0.527	5.84	1,31	0.82
1	62.7	3.1	60.2	5.6	.527	.84	.20	.83
2	62.5	2.7	60.3	4.9	.528	.87	.04	.85
3	61,9	2,7	59.7	4.9	.518	.76	.02	.85
4	61.5	2.6	59.2	4.9	.509	.67	.00	.85
5	61.3	2.4	59.1	4.6	.508	.65	0.94	.86
6	60.9	2.4	58.7	4.6	.501	.58	.93	.86
7	61.0	2.3	58.9	4.4	.504	.62	.89	.86
8	62.2	3.4	59.5	6.1	.515	.71	1.29	.82
9	63.6	5.3	59.4	9.5	.513	.64	2.10	.73
10	64.4	7.2	58.6	13.0	.499	.47	.93	.65
11	65.0	9.0	58.7	15.3	.501	.47	3.57	.61
Noon.	65.4	10.7	57.9	18.2	.488	.29	4.34	.55
1	65.8	11.6	57.7	19.7	.485	.24	.77	.52
2	66.1	12.2	57.6	20.7	.483	.21	5.07	.51
3	66.1	12.5	57.3	21.3	.478	.16	.22	.50
4	65.9	12.0	57.5	20.4	.481	.21	4.95	.51
5	66.0	11.0	58.3	18.7	.494	.35	.54	.54
6	66.4	8.2	60.7	13.9	.536	.83	3.37	.63
7	66.3	6.3	61.3	11.3	.546	.99	2.67	.69
8	65.4	5.5	61.0	9.9	.541	.94	.29	.72
9	64.6	5.1	60.5	9.2	.532	.86	.07	.74
10	64.3	4.3	60.9	7.7	.539	.94	1.73	.77
11	63.9	3.7	60.9	6.7	.539	.96	.48	.80

All the Hygrometrical elements are computed by the Greenwich Constants.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of February, 1866.

Solar Radiation, Weather, &c.

Date.	Max. Solar radiation.	Rain Guage 5 feet above Ground.	Prevailing direction of the Wind.	General Aspect of the Sky.
	o	Inches		
1	...	0.49	N. & N. E.	Overcast to 5 P. M. clear afterwards. Rain from 5 to 10 A. M.
2	124.0	...	N. W. & N.	Clear, slightly foggy at 3 A. M.
3	134.0	...	W. & S. E.	Clear.
4	...	0.33	E.	Clear to 2 A. M. \⌒i to 10 A. M. Overcast afterwards. Rain at 11 A. M. and from 1 to 4 P. M.
5	128.0	...	E. & N. E. & N.	Clear.
6	131.3	...	E.	Clear to 9 A. M. \⌒i to 2 P. M. \—i to 7 P. M. clear afterwards.
7	133.0	...	E.	Clear to 11 A. M. \⌒i to 6 P. M., clear afterwards.
8	125.5	...	E. & N. E.	Clouds of different kinds to 6 P. M., clear afterwards.
9	...	0.10	N. & E.	\⌒i to 3 P. M. overcast afterwards. Thin rain at 11 A. M., 4 and from 7 to 9 P. M.
10	133.8	...	E. & N.	Clear nearly the whole day.
11	122.0	1.56	E. & N.	Clear to 4 A. M. Scatd. \⌒i to 1 P. M. Overcast afterwards. Thunder at 3 & 7 P. M. Rain from 4 to 7 & 10 & 11 P. M.
12	...	1.26	N. & N. W.	Overcast to noon. ⌒i to 5 P. M. clear afterwards. Lightning and Thunder at 2 A. M. Rain at midnight from 2 to 5 & at 7 A. M.
13	128.0	...	N. & N. W.	Clear.
14	136.5	...	W. & N.	Clear.
15	128.5	...	N. & E. & W.	Clear.
16	137.5	...	W. & S.	Clear.
17	139.0	...	W. & E.	Clear to 8 A. M. Scatd. ⌒i to 4 P. M. clear afterwards.
18	...	...	E. & S. & N.	Clear to 7 A. M. overcast to 5 P. M. clear afterwards foggy at 6 & 7 A. M.
19	145.0	...	N. & E. & S.	⌒i and \⌒i to noon. \⌒i to 7 P. M. clear afterwards.
20	...	...	S. & N.	Overcast to 3 P. M. clear afterwards. Thin rain at 9 A. M. & 2 P. M.
21	136.0	...	N. & N. W.	Clear, slightly foggy from 9 to 11 P. M.
22	136.4	...	N. W. & W. & N.	Clear to 9 A. M. Scatd. \—i to 3 P. M. clear afterwards. Slightly foggy at 8 P. M.

\i Cirri, —i Strati, ⌒i Cumuli, \—i Cirro-strati, ⌒—i Cumulo-strati, \⌒—i Nimbi, \⌒i Cirro-cumuli.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of February, 1866.

Solar Radiation, Weather, &c.

Date.	Max. Solar radiation.	Rain Guage 5 feet above Ground.	Prevailing direction of the Wind.	General Aspect of the Sky.
	o	Inches		
23	140.0	...	N. & N. W. & S.	Clear.
24	139.0	...	N. & W.	Clear, slightly foggy at 10 & 11 P. M.
25	139.9	...	N. W. & W. & N.	Clear, slightly foggy at midnight.
26	142.2	..	W.	Clear.
27	141.5	...	W.	Clear, slightly foggy at 6 & 7 A. M.
28	145.0	...	S.	Clear, slightly foggy at midnight and at 6 & 7 A. M.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of February, 1866.

Monthly Results.

	Inches
Mean height of the Barometer for the month,...	29.956
Max. height of the Barometer occurred at 10 A. M. on the 7th, ...	30.138
Min. height of the Barometer occurred at 5 P. M. on the 28th, ...	29.736
Extreme Range of the Barometer during the month, ...	0.402
Mean of the daily Max. Pressures, ...	30.034
Ditto ditto Min. ditto	29.894
Mean daily range of the Barometer during the month, ...	0.140

	o
Mean Dry Bulb Thermometer for the month, ...	70.3
Max. Temperature occurred at 3 P. M. on the 28th, ...	91.4
Min. Temperature occurred at 7 A. M. on the 14th, ...	56.2
Extreme range of the Temperature during the month, ...	35.2
Mean of the daily Max. Temperature, ...	79.2
Ditto ditto Min. ditto, ...	62.9
Mean daily range of the Temperature during the month, ...	16.3

Mean Wet Bulb Thermometer for the month, ...	64.0
Mean Dry Bulb Thermometer above mean Wet Bulb Thermometer, ...	6.3
Computed Mean Dew-point for the month, ...	59.0
Mean Dry Bulb Thermometer above computed mean Dew-point, ...	11.3
	Inches
Mean Elastic force of Vapour for the month, ...	0.506

	Troy grains
Mean Weight of Vapour for the month, ...	5.56
Additional Weight of Vapour required for complete saturation, ...	2.52
Mean degree of humidity for the month, complete saturation being unity,	0.69

	Inches
Rained 5 days, Max. fall of rain during 24 hours, ...	1.56
Total amount of rain during the month, ...	3.74
Total amount of rain indicated by the Gauge attached to the Anemometer during the month, ...	3.34
Prevailing direction of the Wind, ...	E. & N. & W.

Abstract of the Results of the Hourly Meteorological Observations taken at the Surveyor General's Office, Calcutta, in the month of February, 1866.

MONTHLY RESULTS.

Tables showing the number of days on which at a given hour any particular wind blew, together with the number of days on which at the same hour, when any particular wind was blowing, it rained.

Hour.	N.	Rain on.	N. E.	Rain on.	E.	Rain on.	S. E.	Rain on.	S.	Rain on.	S. W.	Rain on.	W.	Rain on.	N. W.	Rain on.	Calm.	Rain on.	Missed.
								No. of days.											
Midnight.	3		3		7	1	3		5				5		2				
1	3		3		7		2		5				5		3				
2	3		3		7	1	3		4				5		3				
3	5		2		6		2		3				5	1	4				1
4	6	1	2		7		1		4				4		3				1
5	7	1	2	1	6		1		5				4		3				
6	8		3	1	5		1		2				4		5				
7	7	1	3	1	6				2				6		4				
8	4		5	1	6				2				6		5				
9	4	2	2		8				2				6		6				
10	5		2	1	10		1		2				6		2				
11	4		1		8	2	3		3				5		4				
Noon.	4		4		6		1		4		1		5		3				
1	2		3		4	1	1		3		1		7		7				
2	3		2		5	1	1		3	1			9		5				
3	7		1		5	1			2		1		8		4				
4	6	2	4	1	2				2				8		6				
5	7		2	1	6		1		1		1		5		5				
6	11		1	1	7				1		1		4		3				
7	14	1			7	1			2				4		1				
8	13	1	1		7				2				4		1				
9	10	1			11				4				3						
10	8		1		9	1			6				3		1				
11	7		1		9	1			6				4		1				

INDEX TO PART II.

The numbers with an asterisk belong to the Special Number on Indian Ethnology.